TRANSACTIONS

AND

PROCEEDINGS

OF THE

ROYAL SOCIETY

OF

NEW SOUTH WALES,

FOR THE YEAR

1875.

VOL. IX.

EDITED BY

A. LIVERSIDGE.

THE AUTHORS OF PAPERS ARE ALONE RESPONSIBLE FOR THE STATEMENTS MADE AND THE OPINIONS EXPRESSED THEREIN.

It is requested that all Communications respecting the printing and publication of the Transactions of the Society may be sent through the Editor.

All Donations presented to the Society are acknowledged by letter, and in the printed Proceedings of the Society.

AGENTS TO THE SOCIETY:

Messrs. Trübner & Co., 57, Ludgate Hill, London, E.C.

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1876.

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VOLUME IX.

The Royal Society of New South Wales.

OFFICERS FOR 1875–6.

PRESIDENT:

HIS EXCELLENCY SIR HERCULES ROBINSON, K.C.M.G.,
&c., &c., &c.

VICE-PRESIDENTS:

REV. W. B. CLARKE, M.A., F.G.S.
THE HON. PROFESSOR SMITH, M.D., F.C.S.

HONORARY TREASURER:

REV. W. SCOTT, M.A.

HONORARY SECRETARIES:

PROFESSOR LIVERSIDGE | DR. ADOLPH LEIBIUS.

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CRACKNELL, E. C.
MANNING, JAMES.
MOORE, CHARLES, F.L.S.
ROLLESTON, CHRISTOPHER.
RUSSELL, H. C., B.A., F.R.A.S.
WRIGHT, H. G. A., M.R.C.S.

ASSISTANT SECRETARY:

CATLETT, W. H.

The Royal Society of New South Wales.

[illegible]

[illegible]

HIS EXCELLENCY SIR HERCULES ROBINSON, [illegible]

VICE-PRESIDENTS.

REV. W. B. CLARKE, M.A., F.R.S. [illegible]

[illegible]

HONORARY TREASURER.

REV. W. SCOTT, M.A.

HONORARY SECRETARIES.

PROFESSOR [illegible]

COUNCIL.

[illegible]

ASSISTANT SECRETARY.

[illegible]

The Royal Society of New South Wales.

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COUNCIL:

LORD, THE HON. F., M.L.C.
MANNING, JAMES.
MOORE, CHARLES, F.L.S.
ROLLESTON, CHRISTOPHER.
SMITH, THE HON. J., M.D., LL.D.
WRIGHT, H. G. A., M.R.C.S.

ASSISTANT SECRETARY:

CATLETT, W. H.

FUNDAMENTAL RULES.

Object of the Society.

1. The object of the Society is to receive at its stated meetings original papers on subjects of Science, Art, Literature, and Philosophy, and especially on such subjects as tend to develop the resources of Australia, and to illustrate its Natural History and Productions.

President.

2. The Governor of New South Wales shall be *ex officio* the President of the Society.

Other Officers.

3. The other Officers of the Society shall consist of two Vice-Presidents, a Treasurer, and two or more Secretaries, who, with six other Members, shall constitute a Council for the management of the affairs of the Society.

Election of Officers.

4. The Vice-Presidents, Treasurer, Secretaries, and the six other Members of Council, shall be elected annually at a General Meeting in the month of May.

Vacancies during the year.

5. Any vacancies occurring in the Council of Management during the year may be filled up by the Council.

Fees.

6. The entrance money paid by Members on their admission shall be One Guinea; and the annual subscription shall be One Guinea, payable in advance.

The sum of Ten Pounds may be paid at any time as a composition for the ordinary annual payment for life.

Honorary Members.

7. The Honorary Members of the Society shall be persons who have been eminent benefactors to this or some other of the Australian Colonies, or distinguished patrons and promoters of the objects of the Society. Every person proposed as an Honorary Member must be recommended by the Council and elected by the Society. Honorary Members shall be exempted from payment of fees and contributions; they may attend the meetings of the Society, and they shall be furnished with copies of Transactions and Proceedings published by the Society, but they shall have no right to hold office, to vote, or otherwise interfere in the business of the Society.

Confirmation of Bye-laws.

8. Bye-laws proposed by the Council of Management shall not be binding until ratified by a General Meeting.

Alteration of Fundamental Rules.

9. No alteration of or addition to the Fundamental Rules of the Society shall be made unless carried at two successive general meetings.

BYE-LAWS.

Passed at a General Meeting of the Society held June 7th, 1876.

Ordinary General Meetings.

1. An Ordinary General Meeting of the Royal Society, to be convened by public advertisement, shall take place at 8 p.m, on the first Wednesday in every month, during the last eight months of the year; subject to alteration by the Council with due notice. These meetings will be open for the reading of papers, and the discussion of subjects of every kind if brought forward in conformity with the Fundamental Rules and By-Laws of the Society.

Annual General Meeting.—Annual Reports.—Election of Officers.

II. A General Meeting of the Society shall be held annually in May, to receive a Report from the Council on the state of the Society, and to elect Officers for the ensuing year. The Treasurer shall also at this meeting present the annual financial statement.

Election of the Officers and Council.

III. The Officers and other members of the Council shall be elected annually *by ballot* at the Annual General Meeting to be held in May.

IV. It shall be the duty of the Council each year to prepare a list containing the names of members whom they recommend for election to the respective offices of Vice-Presidents and Hon. Secretaries and Hon. Treasurer, together with the names of six other members whom they recommend for election as ordinary members of Council. The names thus recommended shall be proposed at one meeting of the Council, and agreed to at a subsequent meeting.

V. Each member present at the General Annual Meeting shall have the power to alter the list of names recommended by the Council, by adding to it the names of any eligible members not already included in it and removing from it an equivalent number of names, and he shall use this list with or without such alterations as a balloting list at the election of Officers and Council.

Council Meetings.

VI. Meetings of the Council of Management shall take place on the last Wednesday in every month, and on such other days as the Council may determine.

Absence from Meetings of Council.—Quorum.

VII. Any member of the Council absenting himself from three consecutive meetings of the Council, without giving a satisfactory explanation in writing, shall be considered to have vacated his office, and the election of a member to fill his place shall be proceeded with at the next Council meeting in accordance with Fundamental Rule V. No business shall be transacted at any meeting of the Council unless three members are present.

Duties of Secretaries.

VIII. The Honorary Secretaries shall perform, or shall cause the Assistant Secretary to perform, the following duties:—

1. Conduct the correspondence of the Society and Council.
2. Attend the General Meetings of the Society and the meetings of the Council, to take minutes of the proceedings of such meetings, and at the commencement of such to read aloud the minutes of the preceding meeting.
3. At the Ordinary Meetings of the members to announce the presents made to the Society since their last meeting; to read the certificates of candidates for admission to the Society, and such original papers communicated to the Society as are not read by their respective authors, and the letters addressed to it.

4. To make abstracts of the papers read at the Ordinary General Meetings, to be inserted in the minutes and printed in the Proceedings.
5. To edit the Transactions of the Society, and to superintend the making of an Index for the same.
6. To be responsible for the arrangement and safe custody of the books, maps, plans, specimens, and other property of the Society.
7. To make an entry of all books, maps, plans, pamphlets, etc., in the Library Catalogue, and of all presentations to the Society in the Donation Book.
8. To keep an account of the issue and return of books, etc., borrowed by members of the Society, and to see that the borrower, in every case, signs for the same in the Library Book.
9. To address to every person elected into the Society a printed copy of the Forms Nos. 2 and 3 (in the Appendix), together with a list of the members, a copy of the Fundamental Rules and Bye-laws, and a card of the dates of meeting; and to acknowledge all donations made to the Society, by Form No. 5.
10. To cause due notice to be given of all Meetings of the Society and Council.
11. To be in attendance at 4 p.m. on the afternoon of Wednesday in each week during the session.
12. To keep a list of the attendances of the members of the Council at the Council Meetings and at the Ordinary General Meetings of the members of the Society, in order that the same may be laid before the Society at the Annual General Meeting held in the month of May.

The Honorary Secretaries shall, by mutual agreement, divide the performance of the duties above enumerated.

The Honorary Secretaries shall, by virtue of their office, be members of all Committees appointed by the Council.

Candidates for Admission.

IX. Every candidate for admission as an ordinary member of the Society shall be recommended according to a prescribed form, by not less than three members, to two of whom he must be personally known.

Election of New Members.

X. The names of such candidates, with the names of their supporters, shall be read by one of the Secretaries at an Ordinary General Meeting of the Society. The vote as to admission to take place by ballot at the next subsequent meeting. At the ballot the assent of at least four-fifths of the members voting shall be requisite for the admission of the candidate.

New Members to be informed of their Election.

XI. Every new member shall receive due notification of his election, and be supplied with a copy of the obligation (No. 3 in Appendix), together with a copy of the Fundamental Rules and Bye-laws of the Society, a list of members, and a card of the dates of meeting.

Members whose subscriptions are unpaid to enjoy no privileges.

XII. An elected member shall not be entitled to attend the meetings nor to enjoy any privilege of the Society, nor shall his name be printed in the list of the Society, until he shall have paid his admission fee and first annual subscription, and have returned to the Secretaries the obligations signed by himself.

Members shall sign Rules—Formal admission.

XIII. Every member who has complied with the preceding Bye-laws shall at the first Ordinary General Meeting at which he shall be present, sign a duplicate of the aforesaid obligation in a book to be kept for that purpose, after which he shall be presented by some member to the Chairman, who, addressing him by name, shall say :—" By the authority and in the name of the Royal Society of New South Wales I admit you a member thereof."

Annual subscriptions, when due.

XIV. Annual subscriptions shall become due on the first of May for the year then commencing. The entrance fee and first year's subscription of a new member shall become due on the day of his election.

Subscriptions in arrears.

XV. Members who have not paid their subscriptions for the current year, on or before the 31st of May, shall be informed of the fact by the Hon. Treasurer.

And at the meeting held in July and at all subsequent meetings for the year, a list of the names of all those members who are in arrears with their annual subscriptions shall be suspended in the Rooms of the Society. Members shall in such cases be informed that their names have been thus posted.

Resignation of Members.

XVI. No member shall be at liberty to withdraw from the Society without previously giving notice to one of the Secretaries of his desire to withdraw, and returning all books or other property belonging to the Society. Members will be considered liable for the payment of all subscriptions due from them up to the date at which they may give notice of their intention to withdraw from the Society.

Expulsion of Members.

XVII. A majority of members present at any ordinary meeting shall have power to expel an obnoxious member from the Society, provided that a resolution to that effect has been moved and seconded at the previous ordinary meeting, and that due notice of the same has been sent in writing to the member in question, within a week after the meeting at which such resolution has been brought forward.

Contributions to the Society.

XVIII. Contributions to the Society, of whatever character, must be sent to one of the Secretaries, to be laid before the

Council of Management. It will be the duty of the Council to arrange for promulgation and discussion at an ordinary meeting such communications as are suitable for that purpose, as well as to dispose of the whole in the manner best adapted to promote the objects of the Society.

Order of Business.

XIX. At the Ordinary General Meetings the business shall be transacted in the following order, unless the Chairman specially decide otherwise :—

1—Minutes of the preceding Meeting.
2—New Members to enrol their names, and be introduced.
3—Ballot for the Election of New Members.
4—Candidates for membership to be proposed.
5—Business arising out of Minutes.
6—Communications from the Council.
7—Communications from the Sections.
8—Donations to be laid on the Table and acknowledged.
9—Correspondence to be read.
10—Motions from last Meeting.
11—Notices of Motion for the next Meeting to be given in.
12—Papers to be read.
13—Discussion.
14—Notice of Papers for the next meeting.

Admission of Visitors.

XX. Every ordinary member shall have the privilege of admitting two friends as visitors to an Ordinary General Meeting of the Society, on the following condition :—

1. That the name and residence of the visitors, together with the name of the member introducing them, be entered in a book at the time.
2. That they shall not have attended two consecutive meetings of the Society in the current year.

The Council shall have power to introduce visitors, irrespective of the above restrictions.

Management of Funds.

XXI. The funds of the Society shall be lodged at a Bank named by the Council of Management. Claims against the Society, when approved by the Council, shall be paid by the Treasurer.

Money Grants.

XXII. Grants of money in aid of scientific purposes from the funds of the Society—to Sections or to members—shall expire on the 1st of November in each year. Such grants, if not expended, may be re-voted.

XXIII. Such grants of money to Committees and individual members shall not be used to defray any personal expenses which a member may incur.

Audit of Accounts.

XXIV. Two Auditors shall be appointed annually, at an ordinary meeting, to audit the Treasurer's Accounts. The accounts as audited to be laid before the Annual Meeting in May.

Property of the Society to be vested in the Vice-Presidents, etc.

XXV. All property whatever belonging to the Society shall be vested in the Vice-Presidents, Hon. Treasurer, and Hon. Secretaries for the time being, in trust for the use of the Society. But the Council shall have control over the disbursements of the funds and the management of the property of the Society.

Library.

XXVI. The Members of the Society shall have access to, and shall be entitled to borrow books from the Library, under such regulations as the Council may think necessary.

Museum.

XXVII. It shall be one of the objects of the Society to form a Museum.

Branch Societies.

XXVIII. The Society shall have power to form Branch Societies in other parts of the Colony.

Sections.

XXIX. To allow those members of the Society who devote attention to particular branches of science fuller opportunities and facilities of meeting and working together with fewer formal restrictions than are necessary at the general monthly meetings of the Society,—Sections or Committees may be established in the following branches of science :—

Section A.—Astronomy, Meteorology, Physics, Mathematics, and Mechanics.

Section B.—Chemistry and Mineralogy, and their application to the Arts and Agriculture.

Section C.—Geology and Palæontology.

Section D.—Biology, *i.e.*, Botany and Zoology, including Entomology.

Section E.—Microscopical Science.

Section F.—Geography and Ethnology.

Section G. — Literature and the Fine Arts, including Architecture.

Section H.—Medical.

Section I—Sanitary and Social Science and Statistics.

Reports from Sections.

XXX. There shall be for each Section a Chairman to preside at the meetings, and a Secretary to keep minutes of the proceedings, who shall jointly prepare and forward to the Hon. Secretaries of the Society, on or before the 7th of November in each year, a report of the proceedings of the Section during that year, in order that the same may be transmitted to the Council.

Section Committees—Card of Meetings.

XXXI. The first meeting of each Section shall be appointed by the Council; at that meeting the members shall elect their own Chairman, Secretary, and a Committee of four; and arrange the days and hours of their future meetings. A card showing the dates of each meeting for the current year shall be printed for distribution amongst the members of the Society.

Money Grants to Sections.

XXXII. By application to the Council, grants of money may be made out of the General Funds of the Society to the Sections.

Membership of Sections.

XXXIII. No person who is not a member of the Society shall have the privilege of joining any of the Sections.

Form No. 1.

ROYAL SOCIETY OF NEW SOUTH WALES.

Certificate of a Candidate for Election.

Name

Qualification or occupation

Address

being desirous of admission into the Royal Society of New South Wales, we, the undersigned, members of the Society, propose and recommend him as a proper person to become a member thereof.

Dated this day of , 18 .

FROM PERSONAL KNOWLEDGE.	FROM GENERAL KNOWLEDGE.

Signature of candidate

Date received 18 .

Form No. 2.

ROYAL SOCIETY OF NEW SOUTH WALES.

The Society's Rooms,

Sir, Sydney, 18 .

I have the honor to inform you that you have this day been elected a member of the Royal Society of New South Wales, and I beg to forward to you a copy of the Fundamental Rules and Bye-laws of the Society, a printed copy of an obligation, a list of members, and a card announcing the dates of meeting during the present session.

According to the Regulations of the Society (*vide* Rule No. 6), you are required to pay your admission fee of one guinea, and annual subscription of one guinea for the current year, before admission. You are also requested to sign and return the enclosed form of obligation at your earliest convenience.

I have the honor to be,

Sir,

Your most obedient servant,

To Hon. Secretary.

Form No. 3.

ROYAL SOCIETY OF NEW SOUTH WALES.

I, the undersigned, do hereby engage that I will endeavour to promote the interests and welfare of the Royal Society of New South Wales, and to observe its Rules and Bye-laws as long as I shall remain a member thereof.

Signed,

Address

Date

Form No. 4.

ROYAL SOCIETY OF NEW SOUTH WALES.

The Society's Rooms,

Sir, Sydney, 18 .

I have the honor to inform you that your annual subscription of one guinea for the current year became due to the Royal Society on the 1st of May last.

I have the honor to be,

Sir,

Your most obedient servant,

To Hon. Treasurer.

Form No. 5.

ROYAL SOCIETY OF NEW SOUTH WALES.

The Society's Rooms,

Sir, Sydney, , 18 .

I am desired by the Royal Society of New South Wales to forward to you a copy of its Transactions for the year 18 , as a donation to the library of your Society.

I am further requested to mention that the Society will be thankful to receive such of the very valuable publications issued by your Society as it may feel disposed to send.

I have the honor to be,

Sir,

Your most obedient servant,

Hon. Secretary.

Form No. 6.

ROYAL SOCIETY OF NEW SOUTH WALES.

The Society's Rooms,

Sir, Sydney, , 18 .

On behalf of the Royal Society of New South Wales, I beg to acknowledge the receipt of , and I am directed to convey to you the best thanks of the Society for your most valuable donation.

I have the honor to be,

Sir,

Your most obedient servant,

To Hon. Secretary.

Form No. 7.

Balloting List for the election of the Officers and Council.

ROYAL SOCIETY OF NEW SOUTH WALES.

May, 18 .

BALLOTING LIST for the election of the Officers and Council.

Present Council.	Names proposed as members of the new Council.	
	Vice-Presidents.	
	Hon. Treasurer.	
	Hon. Secretaries.	
	Members of Council.	

If you wish to substitute any other name in place of that proposed, erase the printed name in the second column, and write opposite to it, in the third, that which you wish to substitute.

ERRATA SLIP.

For the correction of errors, this slip should be filled up and returned to the Hon. Secretaries.

Corrected Address.

Name ....

Titles, &c. ....

Address ....

....

Date ....

CORRIGENDA.

Page.	*Line.*	*For*	*Read*
14	13	was	were
17	17	respence	presence
21	last	he	the
56	19	accute	accurate
171	4	docomposition	decomposition
172	Last but one	FeCo	$FeCo_3$
176	19	$3Pb_3P_2O_8$, PbCl	$3Pb_3P_2O_8$, $PbCl_2$
176	32	$3Pb_3As_2O_8$, PbCl	$3Pb_3As_2O_8$, $PbCl_2$
179	4	Mowemban	Mowembah
188	6	Ozo-kerite	Ozokerite
190	30	former	following
192	34	hard	hand
195	3	anamygdaloidal	an amygdaloidal
198	20	Berrada	Benada
200	36	double-sized	double
204	19	STAURALITE	STAUROLITE
208	17	ζηω	ζέω
212	10	Göetheite	Göthite

LIST OF THE MEMBERS

OF THE

Royal Society of New South Wales.

P Members who have contributed papers which have been published in the Society's Transactions. The numerals indicate the number of such contributions.
† Members of the Council.
‡ Life Members.

Elected.		
1864		Adams, P. F., Surveyor General, Kirribilli Point, St. Leonards.
1874		Alger, John, Macquarie-street.
1870		Allen, The Hon. George, M.L.C., Toxteth Park, Glebe.
1870		Allen, The Hon. George Wigram, M.P., Speaker of the Legislative Assembly, Elizabeth-street North.
1868		Allerding, F., Hunter-street.
1873		Allerding, H. R., Hunter-street.
1856		Allwood, Rev. Canon, B.A., *Cantab.*, Vice-Chancellor, University of Sydney, 259, Macquarie-street.
1876		Alston, John Wilson, M.B. *Edin.*, Mast. Surg. *Edin.*, 455, Pitt-street.
1876		Atchison, Cunningham Archibald, C.E., North Shore.
1873		Atherton, Ebenezer, M.R.C.S. *Eng.*, O'Connell-street.
1873		Austen, Henry, Hunter-street.
1876		Backhouse, Benjamin, Elizabeth Bay.
1876		Barkas, Wm. James, Lic. R. Col. Phys. *Lond.*, M.R.C.S. *Eng.*, Bombala.
1875		Bartels, W. C. W., Union Club.
1875		Bedford, W. J. G., M.R.C.S., *Eng.*, Staff Surgeon.
1868		Beilby, E. T., Macquarie-street.
1875		Belgrave, Thomas B., M.D. *Edin.*, M.R.C.S. *Eng.*, Liverpool-street.
1875		Belisario, John, M.D., Lyons' Terrace.
1869	P 2	Bensusan, S. L., Exchange, Pitt-street.
1856		Bennett, W. C., Department of Public Works, Phillip-street.
1869		Bode, Revd. G. C., St. Leonards, North Shore.
1872		Bolding, H. I., P.M., Newcastle and Union Club.
1869		Boyd, Sprott, M.D. *Edin.*, M.R.C.S. *Eng.*, Lyons' Terrace.
1874		Bowen, George M.C., Keston, Kirribilli Point, North Shore.
1858		Bradridge, Thomas H., Town Hall, George-street.
1876		Brady, Andrew John, Lic. K. & Q. Coll. Phys. *Irel.*, Lic. R. Coll. Sur. *Irel.*, Sydney Infirmary.

Elected.		
1871	P 1	Brazier, John, C.M.Z.S., 11, Windmill-street.
1868		Brereton, John Le Gay, M.D. *St. Andrew's*, L.R.C.S. *Edin.*, Macquarie-street.
1874		Brewster, John, George-street.
1876		Broadribb, W. A., Woollahra.
1876		Brown, Henry Joseph, Newcastle.
1875		Busby, The Hon. William, M.L.C., Redleaf, South Head Road, near Woollahra.
1875		Burton, Edmund, Land Titles Office, Elizabeth-street North.
1876		Cadell, Alfred, Vegetable Creek, New England.
1876		Cadell, Thomas, Wotonga, East St. Leonards.
1876		Cameron, Andrew Robertson, M.D. *Edin.*, Richmond.
1876		Campbell, Allan, L.F. Phys. Surg., *Glasgow*, Yass.
1876		Campbell, The Hon. Alexander, M.L.C., Woollahra.
1868		Campbell, The Hon. Charles, M.L.C., Pine Villa, Newtown.
1872		Campbell, The Hon. John, M.L.C., Campbell's Wharf, Lower George-street.
1870		Cane, Alfred, Stanley-street.
1850	P 17	†Clarke, Rev. W. B., M.A. *Cantab.*, F.R.S., F.G.S., C.M.Z.S., F.R.G.S., Mem. Geol. Soc. France, Corres. Imp. Roy. Geol. Inst. Austria, Hon. Mem. Canterbury Inst., Cor. Mem. Roy. Soc. Tasmania, Fellow of St. Paul's College, *Vice-President*, Branthwaite, St. Leonards, North Shore.
1874		Clay, William French, M.A. *Cantab.*, M.D. *Syd.*, M.R.C.S. *Eng.*, Fellow of St. Paul's Col., North Shore.
1876		Clune, Michael Joseph, Lic. K. & Q. Coll. Phys. *Irel.*, Lic. R. Coll. Surg. *Irel.*, 4, Hyde Park Terrace.
1876		Colyer, John Usher Cox, A.S.N. Company, Sydney.
1856		Comrie, James, Northfield, Kurrajong.
1876		Conder, Wm., Survey Office, Sydney.
1874		Coombes, Edward, Bathurst.
1859	P 2	Cox, James, M.D. *Edin.*, C.M.Z.S., F.L.S., Hunter-street.
1865	P 2	Cracknell, E. C., Superintendent of Telegraphs, Telegraph Office, George-street.
1869		Creed, J. Mildred, M.R.C.S. *Eng.*, Scone.
1870		Croudace, Thomas, Lambton.
1876		Davidson, L. Gordon, M.D., M.C., *Aberdeen*, Goulburn.
1873		Daintrey, Edwin, Æolia, Randwick.
1875		Dangar, Frederick H., Greenknowes, Darlinghurst.
1874		Dansey, John, M.R.C.S. *Eng.*, Wynyard Square.
1876		Dalgarno, John V., Telegraph Office, George-street.
1876		Darley, Cecil West, Newcastle.
1856		Deffell, George H., Clark's street, Hunter's Hill.
1869		De Lissa, Alfred, Pitt-street.
1875		De Salis, The Hon. Leopold Fane, M.L.C., Union Club
1875		De Salis, L. W., junr., Union Club.
1873		Dibbs, George R., M.P., 131, Pitt-street.
1876		Dight, Arthur, Richmond.

Elected.		
1876		Dixon, Douglas, Australian Club.
1875		Dixon, W. A., F.C.S., Hunter-street.
1876		Douglas, James, L.R.C.S. *Edin.*, Glebe Road, Glebe.
1876		Drake, William Hedley, Commercial Bank, Inverell.
1873		Du Faur, Eccleston, F.R.G.S., Rialto Terrace.
1874		Dumaresq, William A.
1876		Egan, Myles, M.R.C.S. *Eng.*, 2, Hyde Park Terrace, Liverpool-street.
1874		Eichler, Charles F., M.D., *Heidelberg*, M.R.C.S. *Eng.*, Bridge-street.
1876		Eldred, W. H., 119, Castlereagh-street.
1875		Eagar, The Hon. Geoffrey, Colonial Treasury, Macquarie-street.
1876		Eales, John, Duckenfield Park, Morpeth.
1876		Evans, George, Como, Darling Point.
1876		Evans, Owen Spencer, M.R.C.S. *Eng.*, Darling-street, Balmain.
1871		Fairfax, Alfred, George-street.
1868		Fairfax, The Hon. John, M.L.C., *Herald* Office, Hunter-street.
1868		Fairfax, James R., *Herald* Office, Hunter-street.
1872		Farnell, J. Squire, M.P., Ryde.
1874		Fischer, Carl F., M.D., F.L.S., Soc. Zool. Bot. Vindob. Socius., 251, Macquarie-street.
1856		Flavelle, John, George-street.
1876		Forde, William, 4, Carlton Terrace, Wynyard Square.
1863		Fortescue, G., M.B. *Lond.*, F.R.C.S., F.L.S., Lyons' Terrace.
1875		Frazer, Hon. John M.L.C., Quirang, Woollahra.
1876		Frean, Richard, M.R.C.S. *Eng.*, Sydney Infirmary.
1876		Frith, Rev. Frank, Wesleyan Parsonage, Newcastle.
1876		Fyffe, Benjamin, M.R.C.S. *Eng.*, Castlereagh-street.
1868	P 1	Garran, Andrew, LL.D. *Syd.*, *Herald* Office, Hunter-street.
1876		Gilchrist, W. O., Union Club.
1875		Gilliat, Henry Alfred, Australian Club.
1876		Gillman, Thomas Henry, B.A., C.M., M.D., Queen's Univ. *Irel.*, Mast. Surg. Queen's Univ. *Irel.*, 20, College-street.
1859		Goodlet, John H., George-street.
1868		Goodchap, Charles, Department of Public Works, Phillip-street.
1876		Graham, The Hon. Wm., M.L.C., Union Club, Sydney.
1873		Greaves, W. A. B., Armidale.
1875		Grundy, F. H., 183, Pitt-street.
1868		Halloran, Henry, Colonial Secretary's Office, Bridge-street.
1864		Hale, Thomas, Gresham-street.
1874		Hardy, J., Hunter-street.

Elected.		
1874		Hay, The Hon. John, M.A. *Glasgow*, M.L.C., President of the Legislative Council, Rose Bay, Woollahra.
1876		Hirst, Geo. D., F.R.A.S., 379, George-street.
1875		Helsham, Douglass, York's Terrace, Glebe.
1876		Heron, Henry, 4, Rialto Terrace, William-street South.
1859		‡Hill, Edward S., C.M.Z.S., Rose Bay, Woollahra.
1868		Holt, The Hon. Thomas, M.L.C., The Warren, near Sydney.
1876		Holroyd, Arthur Todd, M.B. *Cantab.*, M.D. *Edin.*, F.L.S., F.Z.S., F.R.G.S., Master-in-Equity, Sherwood Scrubs, Parramatta.
1870	P 1	Horton, Rev. Thomas, Point Piper Road, Woollahra.
1874		Hurley, John, Mary Villa, Elizabeth Bay Road.
1876		Icely, Thos. R., Carcoar.
1873		Irvine, Francis W., M.D. *Edin.*, St. John's Road, Glebe.
1876		Jackson, Henry William, L.R.C.S. *Edin.*, Lic. R. Phys. *Edin.*, 130, Phillip-street.
1876		Jenkins, Richard Lewis, M.R.C.S., Nepean Towers, Douglass Park.
1874		Jennings, P. A., Edgecliffe Road, Woollahra.
1876		Jones, Richard Theophilus, M.D. *Sydn.*, L.R.C.P. *Edin.*, Ashfield.
1867		Jones, P. Sydney, M.D. *Lond.*, F.R.C.S. *Eng.*, College-street.
1874		Jones, James, Bathurst-street.
1863		Josephson, Joshua Frey, F.G.S., District Court Judge, Enmore Road, Newtown.
1873		Kater, Henry Herman, Burwood.
1876		Keele, Thos. Wm., Harbours and Rivers Department, Phillip-street.
1873		Kennedy, Hugh, B.A. *Oxon.* Registrar of the Sydney University, Enmore Road.
1874		King, Philip G., William-street, Double Bay.
1874		Knox, George, B.A. *Cantab.*, King-street.
1875		Knox, Edward, 24, Bridge-street.
1875		Lackey, The Hon. John, Secretary for Works, M.P., Woodville, near Parramatta.
1875		Lambert, G. P., M.R.C.S. *Eng.*, Phillip-street.
1867	P 2	Lang, Rev. John Dunmore, D.D., M.A. *Glasgow*, Jamison-street.
1876		Langley, W. E., *Herald* Office, Sydney.
1874	P 1	Latta, G. J., O'Connell-street.
1876		Laure, Louis Thos., M.D. Surg. Univ. *Paris*, 131, Castlereagh-street.

Elected.		
1859	P 5	†Leibius, Adolph, Ph. D. *Heidelberg*, Senior Assayer to the Sydney Branch of the Royal Mint, *Hon. Secretary.*
1874		Lenehan, Henry Alfred, Computer, Sydney Observatory.
1872	P 6	†Liversidge, Archibald, F.C.S.; F.G.S.; Assoc. R. S. Mines, *Lond.*; Mem. Phy. Soc. London; Cor. Mem. Roy. Soc. Tas., Professor of Geology and Mineralogy in the University of Sydney, *Hon. Secretary*, Union Club.
1875		Living, John, Marsaloo, North Shore.
1874		Lloyd, George Alfred, M.P., F.R.G.S., O'Connell-street.
1876		†Lord, The Hon. Francis, M.L.C., North Shore.
1876		Lyons, W., M.R.C.S. *Eng.*, Wollongong.
1870		Macafee, Arthur H. C., York-street.
1872		Mackenzie, John, F.G.S., Examiner of Coal Fields, Newcastle.
1874		Mackenzie, W. F., M.R.C.S. *Eng.*, Lyons Terrace.
1876		Mackenzie, Rev. P. F., Paddington.
1876		Mackellar, Chas. Kinnard, M.B., C.M. *Glas.*, Lyons' Terrace.
1876		Maclaurin, Henry Norman, M.D. Univ. *Edin.*, Lic. R. Coll. Sur. *Edin.*, 187, Macquarie-street.
1873		Makin, G. E., Berrima.
1873	P 4	†Manning, James, Milsom's Point, North Shore.
1876		Manning, Frederic Norton, M.D. Univ. *St. And.*, M.R.C.S. *Eng.*, Lic. Soc. Apoth. *Lond.*, Gladesville.
1869		Mansfield, G. A., Pitt-street.
1872		Marsden, The Right Rev. Dr., Bishop of Bathurst, Bathurst.
1876		Marshall, George, M.D. Univ. *Glas.*, Lic. R. Coll. S. *Edin.*, Lyons' Terrace.
1876		Marsh, J. M., P.M., Edgecliff Road, Woollahra.
1875		Mathews, R. H.
1874		M'Cutcheon, John Warner, Assayer to the Sydney Branch of the Royal Mint.
1876		McCarthy, W. F., Deepdeen, Glenmore Road.
1859		M'Donnell, William, George-street.
1868		M'Donnell, William J., F.R.A.S., George-street.
1876		McGuire, W. H., Telegraph Office, George-street.
1876		M'Kay, Charles, M.D. Univ. *St. And.*, Lic. R. Coll. Surg. *Edin.*, Church Hill.
1868		Metcalfe, Michael, Bridge-street.
1873		Milford, F., M.D. *Heidelberg*, M.R.C.S. *Eng.*, College-street.
1875		Moir, James, Margaret-street.
1875		Montefiore, E. L., Macleay-street.
1856	P 4	†Moore, Charles, F.L.S., Director of the Botanic Gardens, Botanic Gardens.
		Morehead, R. A. A, 30, O'Connell-street.
1865	P 1	Morrell, G. A., C.E., Department of Works, Phillip-street.
1872		Morgan, Cosby William, M.D. *Brussels*, L.R.C.P. *Lond.*, 1, Grosvenor-terrace, Church Hill.
1876		Morgan, Allan Bradley, M.R.C.S. *Eng.*, Lic. Mid. Lic. R. Coll. Phys. *Edin.*, Ashenhurst, Burwood.
1865		Murnin, M. E., Exchange, Bridge-street.
1876		Murray, W. G., Macquarie-street.
1876		Myles, Chas. Henry, Wymela, Burwood.

Elected.		
1876		Neild, John Cash, M.R.C.S. *Eng.*, Lic. Soc. Apoth. *Lond.*, Sydney.
1873		Neill, William, City Bank, Pitt-street.
1874		Neill, A. L. P., City Bank, Pitt-street.
1874		Nicol, D., Burwood.
1873		Norton, James, Elizabeth-street.
1875		Nott, Thomas, M.D. *Aberdeen*, M.R.C.S. *Eng.*, Woollahra.
1875		O'Reilly, W. W. J., M.D., M.C., *Q. Univ. Irel.*, M.R.C.S. *Eng.*, Liverpool-street.
1876		Osborne, James, Wollongong.
1875		Owen, The Hon. Robert, M.L.C., 88, Elizabeth-street.
1875		Palmer, J. H., Legislative Assembly.
1876		Parrot, Thomas S., Ashfield.
1861		Paterson, Hugh, Macquarie-street.
1874		Pedley, Frederick, Wynyard-square.
1856	P 5	Pell, M.B., B.A. *Cantab.*, late Fellow of St. John's College, Camb.; Professor of Mathematics in the University of Sydney.
1872		Pendergast, Robert, Hay-street.
1875		Phillip, H., Pacific Insurance Company.
1862		Prince, Henry, George-street.
1876		Quaife, Fredk. Harrison, M.D., Mast. Surg. Univ. *Glas.*, Piper-street, Woollahra.
1865		‡Ramsay, Edward, F.L.S., Curator of the Australian Museum, College-street.
1874		Raymond, L. C., Union Bank.
1874		Read, Reginald Bligh, M.R.C.S. *Eng.*, Randwick.
1868		Reading, E., Mem. Odont. Soc. *Lon.*, Castlereagh-street.
1870		Renwick, Arthur, M.D. *Edin.*, B.A. *Sydn.*, F.R.C.S.E., 295, Elizabeth-street.
1856		Roberts, J., George-street.
1868	P 7	Roberts, Alfred, M.R.C.S. *Eng.*, Hon. Mem. Zool. and Bot. Soc. Vienna, Phillip-street.
1876		Roberts, Rev. W. H., B.A., *Dublin*, St. Paul's College, Newtown.
1871		Robertson, Thomas, M.P., Pitt-street North.
1872		Robinson, His Excellency Sir Hercules, K.C.M.G., Governor of New South Wales, Government House.
1873		Rogers, Rev. Edward, Rural Dean, Fort-street.
1856	P10	†Rolleston, Christopher, Auditor General, Castlereagh-street.
1865		Ross, J. Grafton, 24, Bridge-street.
1864	P 8	†Russell, Henry C., B.A. *Syd.*, F.R.A.S., F.M.S., Government Astronomer, Sydney Observatory, *Vice-President.*

Elected.		
1875		Sahl, Charles L., German Consul, Consulate of the German Empire, Wynyard Square.
1876		Saliniere, Rev. E. M., Glebe.
1876		Samuel, The Hon. Saul, C.M.G., M.L.C., Gresham-street.
1876		Schuette, Rudolf, M.D., Univ. *Göttingen*, Lic. Soc. Apoth. *Lond.*, 10, College-street.
1856	P 8	†‡Scott, Rev. William, M.A. *Cantab.*, Hon. Mem. Roy. Soc. Vic., Warden of St. Paul's College, *Hon. Treasurer*, St. Paul's College, Newtown.
1876		Sedgwick, Wm. Gillett, M.R.C.S. *Eng.*, Newtown.
1876		Sharp, James Burleigh, J.P., Yass.
1875		Sheppard, Rev. G., Elizabeth-street.
1873		Simon, Eugene, Consul for France, French Consulate, George-street.
1872		Sleep, John S., 139, Pitt-street.
1852	P 7	†Smith, John, The Hon. M.D., LL.D., *Aberdeen*, M.L.C., F.C.S., Hon. Mem. New Zealand Inst., Hon. Mem. Roy. Soc. Vic., Professor of Physics and Chemistry in the University of Sydney, 193, Macquarie-street.
1875		Smith, Robt., B.A., *Syd.*, Solicitor, Bridge-street.
1874		Smith, John M'Garvie, 404, George-street.
1875		Slade, G.P., Wheatley, North Shore.
1876		Southey, H. E., Oaklands, Mittagong.
1870		Spencer, Walter W., Lyons' Terrace.
1876		Stackhouse, Thos., Commander R.N., Australian Club.
1874		Stephen, Edward M., Macleay-street.
1872	P 1	Stephen, George Milner, B.A., F.G.S., Mem. Geol. Soc. of Germany; Cor. Mem. Nat. Hist. Soc., Dresden; F.R.G.S. of Cornwall; Ashfield.
1857		Stephens, William John, M.A. *Oxon.*, 223, Darlinghurst Road.
1876		Strong, Wm. Edmund, M.D. *Aberdeen*, M.R.C.S. *Eng.*, Liverpool.
1874		Stuart, The Hon. Alexander, M.P., Colonial Treasurer, Clunes, Cambridge-street, South Kingston, Petersham.
1872		Tarleton, Waldyre W., M.A. *Syd.*, Waverley.
1874		Taylor, Chas., M.D. *Syd.*, M.R.C.S. *Eng.*, Parramatta.
1876		Tayler, William George, F.R.C.S. *Lond.*, 219, Pitt-street.
1862	P 4	Tebbutt, John, junr., F.R.A.S., Private Observatory, Windsor.
1870	P 1	Thompson, H. A., O'Connell-street.
1875		Thompson, Joseph, Potts' Point.
1876		Thomas, H., Arding, Narellan.
1876		Tibbits, Walter Hugh, Dubbo.
1876		Toohey, J. T., Melrose Cottage, Cleveland-street.
1873		Trebeck, Prosper N., George-street.
1876		Trouton, F. H., A.S.N. Company's Offices, Sydney.
1868		Tucker, William, Clifton, North Shore.
1875		Tulloh, W. H., Margaret-street.
1875		Turner, G., Argyle Terrace, Redfern.

Elected.	
1874	Vessey, Leonard A., Survey Office.
1876	Voss, Houlton H., 189, Macquarie-street.
1867	Walker, Philip B., Telegraph Office, George-street.
1870	Wallis, William, Moncur Lodge, Potts' Point.
1876	Waterhouse, J., M.A. *Syd.*, Newington College, Parramatta.
1876	Watkins, John Leo., B.A. *Cantab.*, M.A. *Syd.*, Randwick.
1876	Watson, C. Russell, M.R.C.S. *Eng.*, Newtown Road, Newtown.
1859	Watt, Charles, New Pitt-street.
1874	Watt, John B., The Hon. M.L.C., 104, Macleay-street.
1867	Ward, R. D., M.R.C.S. *Eng.*, North Shore.
1876	Waugh, Isaac, M.B., M.C., *T.C.D.*, Parramatta.
1876	Webster, A. S., Union Club.
1867	Weigall, Albert Bythesea, B.A. *Oxon.*, M.A. *Syd.*, Head Master of the Sydney Grammar School, College-street.
1876	Wilson, F. H., Newtown.
1876	Windeyer, W. C., M.A. *Syd.*, King-street.
1876	Wise, George Foster, Darlinghurst.
1874	White, Rev. James S., M.A., LL.D., *Syd.*, Gowrie, Singleton.
1875	White, Hon. James, M.L.C., Cranbrook, Double Bay.
1874	Wilkinson, C. S., Government Geologist, Department of Mines.
1862	Williams, J. P., New Pitt-street.
1876	Williams, Percy, Treasury.
1873	Wood, Harrie, Under Secretary for Mines, Department of Mines.
1874	Woodgate, E., Parramatta.
1872	Wright, Horatio, G. A., M.R.C.S. *Eng.*, F.R.A.S., Wynyard Square.

Honorary Members.

Elected, August, 1875.

Agnew, Dr., Hon. Secretary, Royal Society of Tasmania, Hobart Town.

Barlee, The Hon. F., Colonial Secretary of Western Australia, Perth.

Bernays, Lewis A., F.L.S., Vice-President of the Queensland Acclimatization Society, Brisbane.

Ellery, Robert F., F.R.S., F.R.A.S., Government Astronomer of Victoria, Melbourne.

Gregory, Augustus Charles, F.R.G.S., Surveyor General of Queensland, Brisbane.

Haast, Dr. Julius von, Ph. D., F.R.S., F.G.S., Government Geologist and Director of the Canterbury Museum, New Zealand.

Hector, James, C.M.G., M.D., F.R.S., Director of the Colonial Museum and Geological Survey of New Zealand, Wellington.

M'Coy, Frederick, F.G.S., Hon., F.C.P.S., C.M.Z.S., Professor of Natural Science in the Melbourne University, Government Palæontologist, and Director of the National Museum, Melbourne.

Müller, Baron Ferdinand von, C.M.G., M.D., Ph. D., F.R.S., F.L.S., Government Botanist, Melbourne.

Schomburgh, Dr., Director of the Botanic Gardens, Adelaide, South Australia.

Waterhouse, F. G., F.G.S., C.M.Z.S., Curator of the Museum, Adelaide, South Australia.

Woods, Rev. Julian E. Tenison, F.G.S., F.R.G.S., Hon. Mem. Roy. Soc., Vic., Hobart Town, Tasmania.

Obituary, 1875.

Elected.

1875. Goodenough, Commodore, R.N., C.B., C.M.G.

1868. Hovell, Capt., Goulburn.

1867. Reed, Howard, *Herald* Office.

1872. Pierce, John, Maitland.

1875. Cameron, Ewen, Balmain.

PROCEEDINGS OF THE ROYAL SOCIETY OF NEW SOUTH WALES.

WEDNESDAY, 12TH MAY, 1875, ANNIVERSARY MEETING.

THE REV. W. B. CLARKE, M.A., F.G.S., Vice-President, in the Chair.

The Minutes of the last meeting were read and confirmed.

The following gentlemen were duly elected ordinary members of the Society, viz. :—

Dr. Nott, Woollahra,
Fred. H. Dangar, Macleay-street.

Eight new candidates were proposed and seconded.

The following Financial Statement for the year ending 30th April, 1875, was read by the Acting Honorary Treasurer :—

RECEIPTS.

	£	s.	d.
To Balance in the Union Bank on the 30th April, 1874	£ 94	1	4
„ Subscriptions and Entrance Fees	139	14	0
	£233	15	4

DISBURSEMENTS.

	£	s.	d.
By Rent of Masonic Hall	£6	6	0
„ Rent of Chamber of Commerce	10	10	0
„ Advertisements	6	15	4
„ Cartage and cab hire	5	1	9
„ Elliott Brothers, sulphuric acid	2	16	0
„ Refreshments for conversazione	34	14	0
„ Cunninghame & Co., printing	5	3	0
„ Foy, hire of lamps	0	17	6
„ Moore, Henderson, & Boucher, red cloth	4	16	0
„ H. W. Ingram, commission	8	0	7
„ Petty cash account	13	4	0
„ Wages	5	11	2
„ Assistant Secretary's salary to 31st Dec., 1874	40	0	0
„ Balance in the Union Bank	90	0	0
	£233	15	4

It was then proposed by Mr. James Norton, seconded by Mr. Vessey, and carried :—That the following gentlemen be elected Officers of the Society for the current year, viz. :—

VICE-PRESIDENTS:

Rev. W. B. CLARKE, M.A., F.G.S.
The Honorable JOHN SMITH, M.L.C., M.D.

HONORARY TREASURER:

Rev. WILLIAM SCOTT, M.A.

HONORARY SECRETARIES:

Professor LIVERSIDGE. Dr. LEIBIUS.

COUNCIL:

E. C. CRACKNELL, Esq.
JAMES MANNING, Esq.
CHARLES MOORE, Esq., F.L.S.
CHRIS. ROLLESTON, Esq.
H. C. RUSSELL, Esq., B.A., F.R.A.S.
H. G. A. WRIGHT, Esq., M.R.C.S.

The following donations were laid upon the table by the Chairman, viz. :—

"Victorian Year Book," containing a digest of the Statistics of the Colony for the year 1873, by Henry Haylyn Hayter, Government Statist of Victoria.

"Results of Observations in Meteorology and Terrestrial Magnetism," taken at the Melbourne Observatory during the year 1872, together with Abstracts from Meteorological Observations obtained at various localities in Victoria, under the superintendence of Robert L. J. Ellery, Government Astronomer.—Vol. I.

"Statistics of the Colony of Victoria," from the Government Statist.

"Ninth Annual Report of the Colonial Museum and Laboratory," from the Colonial Museum, Wellington.

The Anniversary Address by the Rev. W. B. Clarke, Senior Vice-President, was then read by Mr. Chris. Rolleston, and Professor Liversidge.

Mr. Rolleston moved :—That the thanks of the Society be given to the Rev. W. B. Clarke for his valuable address.

Mr. Bensusan said, that in rising to second the vote of thanks to the Rev. W. B. Clarke for his able and interesting address, he did so with more than ordinary pleasure; he was glad to see the claims of Mons. Garnier so fully vindicated, partly because it was his due, but principally because it afforded him an opportunity of explaining how it was that his absent friend Mr. Vale and himself respectively, had become wrongfully possessed of the prestige of being the first to determine the character of the valuable discoveries of nickel and chromate of iron in New Caledonia. He might mention, that for some time

past a great many mineral specimens were sent up from New Caledonia, both to Mr. Vale and himself, for determination. Mr. Vale had received a specimen of nickel ore and reported upon it, and Mr. Bensusan had some chromate of iron sent to him about the same time, on which he also reported. By some mistake a paragraph appeared in the *Herald*, giving Mr. Bensusan the credit of the nickel discovery, whereupon he at once wrote to disclaim that honor, hazarding the suggestion that the mistake might possibly have occurred through his having almost simultaneously reported on the chrome discoveries. At that time the researches years previously of M. Garnier, were comparatively unknown; but in justice to Mr. Vale, it might be alleged that he had never, so far as the speaker was aware, claimed to be the discoverer of the nickel.

Mr. Bensusan read passages from letters received from New Caledonia, stating that on the report of M. Garnier a company had been formed in France, and that they sent out a staff of men to work the chrome ores; but these men could find none, and returned to France; that subsequently fifty tons of the supposed chromate of iron was sent home to Brest, and found to be magnetic oxide of iron only. Instead however of regretting the mistake which had occurred, he considered it a cause for congratulation, as it had been the means of calling forth from the Rev. W. B. Clarke the interesting, instructive, and exhaustive paper with which the members had this evening been gratified.

The vote of thanks to Mr. Clarke was carried unanimously.

Mr. Bensusan exhibited some specimens of chrome colours, recently made in New Caledonia, from chromate of iron, lemon green, green, cinnabar red, &c., and stated that a M. Quinquet had recently discovered a method of making from chrome ore a beautiful green colour for wall papers, rivalling in brilliancy the well known Scheele's green, without possessing its poisonous arsenical combinations.

The meeting then adjourned until the 2nd June.

WEDNESDAY, 2nd JUNE, 1875.

Chris. Rolleston, Esq., in the Chair.

The minutes of the last meeting were read and confirmed.

The following gentlemen were duly elected ordinary members of the Society, viz.:—

John Living,	C. H. Sahl,
The Hon. Geoffrey Eagar,	E. L. Montefiore,
The Hon. John Lackey, M.P.,	Edmund Burton,
G. P. Slade,	Henry Alfred Gilliat.

Five new candidates were proposed and seconded.

The following donations were laid upon the table :—

"Statistical Register of the Colony of Victoria for the year 1874"; Parts, 1, 2, 3. Blue Book.

"Agricultural Statistics, 1874–75," from the Government Statist of Victoria.

"Studies from the Physiological Laboratory in the University of Cambridge." Part 1, from Professor Liversidge.

"Proceedings of the Royal Society of London." Vol. XXIII, Nos. 157 and 158, from the Royal Society.

"Results of Meteorological Observations made in New South Wales, during the year 1873," from the Government Observatory, Sydney.

"Transactions of the Royal Society of Tasmania." Vol. I of old series, Vol. II of old series, Vol. III, parts 1 and 2 of old series. New series, 1863 to 1868 inclusive.

Mr. S. L. Bensusan then read his paper entitled, "Facts in American Mining."

Mr. Bensusan displayed some fine samples of silicate of nickel from New Caledonia, together with samples of metallic nickel, extracted here by a commercial process from the ore, and stated that an approved process may be adopted here with advantage, and that the principal credit for that improvement is due to Mr. Latta. Also samples of very fine chromate of iron from the same place. Specimens of coal from the neighbourhood of Noumea was also shown, but the age was undetermined, owing to the absence of any of the characteristic fossils. Mr. Bensusan also showed specimens of vein and stream tin from Mount Bischoff, Tasmania, and bismuth from Mount Ramsay, Tasmania.

The meeting then adjourned until the 7th July.

WEDNESDAY, 7TH JULY, 1875.

The Honorable John Smith, M.D., in the Chair.

The Minutes of the last meeting were read and confirmed.

The following gentlemen were duly elected ordinary members of the Society, viz. :—

W. H. Tulloh,	Thos. B. Belgrave, M.D.,
R. H. Matthews,	Rev. George Sheppard, B.A.,
George Turner.	

Six new candidates were proposed and seconded.

The "Statistical Register of the Colony of Victoria for 1874," Part 4, Law, Crime, &c., was laid upon the table by the Chairman,

as a donation to the Society from the Government Statist of Victoria.

The CHAIRMAN then intimated to the members that the Council wished the rules for the introduction of new members to the Chair by their proposers and seconders to be carried out. That the Council had determined to hold their meetings on the first Wednesday of every month during the session, whether they had a paper to read or not, and if they had no paper, to have a meeting simply of a conversational character.

The CHAIRMAN also called the attention of the members to the by-laws for the admission of visitors, and the rule for the election of honorary members.

The CHAIRMAN further stated that the Council of the Society had, in accordance with the above rule, nominated the following gentlemen as honorary members, their election to take place at the next meeting, viz. :—

Professor M'Coy, Baron von Müller, and Robert L. J. Ellery, F.R.S., of Victoria.
Dr. Hector, F.R.S., and Dr. J. von Haast, F.R.S., of New Zealand.
Lewis A. Bernays, F.L.S., V.P. of the Acclimatization Society of Queensland.
Dr. Agnew, of Tasmania.
Dr. Schomburgh, of South Australia, and
The Honorable F. Barlee, Colonial Secretary of Western Australia.

The CHAIRMAN also stated, that the Secretaries had been writing to scientific Societies in Europe and America, for an exchange of their transactions and publications, and that they had also put themselves in communication with the foreign Consuls, resident in Sydney, for the same purpose.

A paper "On the Stanniferous Deposits of Tasmania," by Mr. Wintle, was read by Professor LIVERSIDGE, and illustrated by specimens sent for that purpose per favour of the Rev. W. B. CLARKE.

Mr. M'CUTCHEON asked the Chairman how it was that among the list of honorary members of the Society to be elected at their next meeting, no gentleman had been proposed who was a resident in New South Wales.

The CHAIRMAN said, that the impression of the Council had been that they should not elect, as honorary members, gentlemen who were in their own Colony. Scientific men in this Colony could join and identify themselves with the Society. They had very great difficulty in selecting one or two eminent men in each Colony, and not going further.

Mr. M'CUTCHEON submitted that the rule which spoke of the election of honorary members applied to scientific men of eminence in this Colony.

The Rev. WM. SCOTT said that, if they made honorary members of some of the leading members they would remove them from their present active positions, to the detriment of the Society.

After some further discussion the matter was referred to the Council for re-consideration.

The meeting then adjourned until the 1st August.

WEDNESDAY, 4TH AUGUST, 1875.

REV. W. B. CLARKE, V.P., in the Chair.

The Minutes of the last meeting were read and confirmed.

The following gentlemen were duly elected ordinary members of the Society, viz.:—

Ewen W. Cameron,
W. A. Dixon, F.C.S.,
Douglas Helsham,
The Hon. Leopold Fane De Salis, M.L.C.,
L. W. Fane De Salis, M.P.,
W. C. W. Bartels.

Four new candidates were proposed and seconded.

The CHAIRMAN said, that at the last meeting it had been suggested that gentlemen living in this Colony might be elected as honorary members, but it was decided by the Council that it would be unadvisable to do this, on the grounds that gentlemen residing in the Colony should become connected with the Society in the usual way as subscribing members, and that making residents of this Colony honorary members would be taking away from the working members of the Society, to its great detriment.

The following gentlemen having been proposed by the Council as Honorary Members of the Society, were unanimously elected by the members present, viz.:—

Professor M'Coy, F.G.S.,
Baron Von Müller, F.R.S.,
Robt. L. J. Ellery, F.R.S.,
Dr. Hector, F.R.S.,
Lewis A. Bernays, F.L.S.,
Dr. Agnew,
Dr. Schomburgh,
The Hon. F. Barlee, F.R.G.S.,
Dr. J. von Haast, F.R.S.

The CHAIRMAN then said, that the Council had also nominated the following gentlemen as Honorary Members, viz:—

Augustus Charles Gregory, Surveyor General of Queensland, F.R.G.S., and Medallist.

F. G. Waterhouse, F.G.S., C.M.Z.S., Naturalist of the Stuart Expedition overland to the North-west Coast.

Revd. Julian E. T. Woods, F.G.S., F.R.G.S., F.L.S., Author of various Geological Works on South Australia, Victoria, and North Australia.

Moved by Mr. Read, M.R.C.S. :—That the three gentlemen just named by the Chairman be at once elected Honorary Members. The motion having been seconded, was carried unanimously.

The following donations was laid upon the Table, viz. :—

"Statistical Register of the Colony of Victoria, 1874"; Part 4, Law, Crime, &c. ; from the Government Statist of Victoria.

"Reasons Suggestive of Mining on Physical Principles for Gold and Coal ;" from the Author, J. Wood Beilby.

Mr. James Manning then read his paper—"On the Sydney Water Supply by Gravitation," which he illustrated by diagrams and maps.

The discussion on the above paper was postponed until the next meeting.

The meeting then adjourned until the 1st September.

WEDNESDAY, 1st SEPTEMBER, 1875.

The Rev. W. B. Clarke, V.P., in the Chair.

The minutes of the last meeting were read and confirmed.

The following gentlemen were duly elected ordinary members of the Society, viz. :—

James Hugh Palmer,	John Belisario, M.D.,
Joseph Thompson,	Francis H. Grundy.

Two new candidates were proposed and seconded.

The Vice-President announced the receipt of letters acknowledging the election as Honorary Members of Mr. Ellery, Government Astronomer, of Victoria ; Dr. Agnew, of Hobart Town ; Mr. Lewis A. Bernays, of Brisbane ; and Baron Von Müller, of Melbourne.

The following donations were laid upon the Table by the Chairman, viz. —

"Transactions and Proceedings of the New Zealand Institute, 1874," Vol. VII ; from the Colonial Museum, Wellington.

"Fragmenta Phytographica Australia," Vols. VII and VIII, from Baron Von Müller.

Mr. James Manning then read an Appendix to his paper, "On the Sydney Water Supply by Gravitation."

A discussion ensued, in which Dr. Read, Mr. Chas. Moore, Dr. Leibius, Dr. Belgrave, the Hon. Leopold Fane De Salis, Mr. Trebeck, and the Chairman took part.

The meeting then adjourned until the 6th October.

WEDNESDAY, 6TH OCTOBER, 1875.

MR. CHRISTOPHER ROLLESTON in the Chair.

The minutes of the last meeting were read and confirmed.

The following gentlemen were duly elected ordinary members of the Society, viz.:—

James Moir, Robert Smith, B.A.

Two new candidates were proposed and seconded.

The CHAIRMAN announced that letters of acknowledgment had been received from the following honorary members of the Society, viz.:—Mr. Waterhouse, Adelaide, Dr. Schomburgh, J. E. Tenison Woods, F.L.S., and Professor M'Coy, F.G.S., Melbourne.

The CHAIRMAN laid the following donations upon the table:—

"Proceedings of the Royal Society," Vol. XXIII, Nos. 159 and 161; from the Royal Society of London.

"Records of the Geological Survey of India," Vol. VII, Parts 1, 2, 3, and 4; from the Geological Museum, Calcutta.

"Memoirs of the Geological Surveys of India," Vol. X, Part 2, and Vol. XI, Part 1.

"Memoirs of the Geological Survey of India," Palæontologia India; Part 1, section 10.

"Forhandlinger i Vitenskaps-Selskabel, I. Christiania," Aar 1872.

"Forhandlinger i Vitenskaps-Selskabel, I. Christiania," Aar 1873. Andet Hefti.

"Forhandlinger i Vitenskaps-Selskabel, I. Christiania," Aar 1873. Forsti Hefte.

"Postola Sogur," C. R. Unger.

"XI und XII, Yahresbericht des Veriens für Erdkunde zu Dresden."

"Om Skuringsmærker Glacialformationem Terrasser," og Strandlinier samt Om goundfjeldets og Sparagmitfjeldets mægtighed i Norze.

"Jættigryder og Gamle Strandlinier i fast Klippe," ap. S. A. Lexe.

"Grundtrækkeue i Den Ældste Norske. Proces" af Ebbe Hartzberg ved Dr. F. Brandt.
"Die Ægyptischen Denkmäler in St. Petersburg, Helsingfors, Upsala, und Copenhagen, von J. Lieblien. Two copies.
"Neue Integrations-Methode eines 2n.-Gliedrigen." Pfaffschen Problems, von Sophus Lie.
"I Anledning af Schopenhauers af det throndhiemske Videnskabers-Selskab belonnede Priis-Afhandling om den frie Villies Forhold til Selvbevidstheden, ap., M. J. Monrad.
"Partielle Differential Gleichungen 1. 0. in denen die unbekannte Funktion explicite vorkommt, von Sephus Lie.
"Bemærkninger i Anledning af Assessor Hjelms Foredrag: Strobemœrkninger om Bevidsthedens Væsen, af Prof. Dr. F. C. Faye.
"Zur Erklärnug des Polybius 6, 20, von P. O. Schjott.
From the Secretary to the Royal University of Christiania.

Mr. James Manning then read his paper "On the Water Supply to Sydney by Gravitation."

A discussion ensued, in which the Rev. Wm. Scott, Messrs. Bensusan, Biggar, Roberts, Alger, Dr. Belgrave, the Hon. L. Fane de Salis, the Hon. Chas. Campbell, the Hon. Robert Owen, and the Chairman took part.

It was moved by Mr. Alfred Roberts, seconded by Dr. Belgrave, and carried:—That this meeting requests that the Council will forthwith consider whether the Society can judiciously petition the Government in respect to the reservation of the land described by Mr. James Manning, until the subject has been further investigated, and that this meeting stand adjourned until this day week, to receive the Council's report.

WEDNESDAY, 13th OCTOBER, 1875, ADJOURNED MEETING.

Chris. Rolleston, Esq., in the chair.

The Chairman said, that the following resolution, moved by Mr. Alfred Roberts, had been carried at the last meeting, viz.:—"That this meeting request that the Council of the Society will forthwith consider whether the Society can judiciously petition the Government in respect to the reservation of the land described by Mr. James Manning, until the subject has been further investigated, and that this meeting stand adjourned until this day week, to receive the Council's report." The Council met to-day to consider the resolution, and believing that it would

not be right for them to petition the Government they had come to the following resolution :—"The Council are of opinion that there would be no objection to the meeting appointing a deputation to wait upon the Honorable the Colonial Secretary to recommend the reservation of the watersheds as described in Mr. James Manning's scheme for supplying Sydney with water by gravitation."

It was then moved by Dr. BELGRAVE, seconded by Mr. JAMES NORTON, and carried :—That a deputation, consisting of the Rev. Dr. Lang, Mr. Alfred Roberts, Mr. Alger, and the mover, be appointed to wait upon the Honorable the Colonial Secretary, to recommend the Government to reserve the watersheds as described in Mr. James Manning's scheme.

WEDNESDAY, 3RD NOVEMBER, 1875.

THE REV. W. B. CLARKE, V.P., in the Chair.

The minutes of the meeting of the 6th October, and the minutes of the adjourned meeting of the 13th October, were read and confirmed.

The following gentlemen were duly elected ordinary members of the Society, viz. ;—

George P. Lambert, W. W. J. O'Reilly, M.D.

Five new candidates were proposed and seconded.

The following donations were laid upon the table, viz. :—

"Statistical Register for the Colony of Victoria, for the year 1874," Part 5. Interchange from the Government Statist of Victoria.

"Mines and Mineral Statistics of New South Wales," and "Notes of the Geological Collection of the Department of Mines," from the Honorable John Lucas, Minister for Mines.

Descriptive papers relating to the School of Mines, Ballaarat, by the Special Reporter of the *Ballarat Star*, from the Registrar of the School of Mines.

The CHAIRMAN announced that letters of acknowledgment had been received from the following honorary members of the Society, viz. :—Dr. Julius von Haast, F.R.S., Dr. Hector, F.R.S., and the Honorable F. Barlee, F.R.G.S.

A letter was read from the Honorary Secretary of the Royal Colonial Institute, London, dated July, 1875, enclosing a copy of some new regulations adopted by the Council of that Institute, in reference to the admission of honorary members.

Moved by PROFESSOR SMITH, seconded by MR. HY. RUSSELL, and carried :—That the Council be requested to acknowledge the receipt of the letter with thanks, and to take such action in the matter as will place the Royal Society of New South Wales on reciprocal relations with the Royal Colonial Institute.

The following report was read, and handed in to the Chairman by Dr. Belgrave, viz. :—

The deputation appointed by the Society at its last meeting to wait upon the Honorable the Colonial Secretary, with a view to induce the Government to reserve from alienation from the public estate the land recommended to be utilised by Mr. Manning as a gathering ground in his scheme for supplying Sydney and the intervening country with water, has the honor to report, that it had an interview with the Honorable John Robertson, on the 21st October. The deputation found the Premier thoroughly familiar with the question ; and received a promise that on a map of the land proposed to be reserved being furnished, the wish of the Society, as far as practicable, would be complied with. The deputation was also informed by the Colonial Secretary, that the Government recognized the necessity for furnishing an early adequate supply of water to Sydney; and that the Representative in London of the Colony had received instructions to communicate with the President of the Society of Civil Engineers, and to place an adequate sum of money at the disposal of that gentleman to furnish the Government with the necessary advice on the subject.

On MR. ROLLESTON'S motion the report was received, and adopted.

MR. RUSSELL then read a paper entitled "Scientific Notes."

WEDNESDAY, 1ST DECEMBER, 1875.

The minutes of the last meeting were read and confirmed.

The following gentlemen were duly elected ordinary members of the Society, viz. :—

George Dentan Hirst,	The Hon. James White, M.L.C.,
J. A. Bedford, M.R.C.S.,	The Hon. John Frazer, M.L.C.,

Thomas Cadell.

Five new candidates were proposed and seconded.

The following donations were laid upon the table by the Chairman, viz. :—

"Statistical Register of the Colony 1874," Part 4, Law, Crime, &c. ; Part 6, Production ; Part 7, Accumulation.

"Australian Statistics for the year 1874, with introductory report," from the Government Statist of Victoria.

"Annual Report of the South Australian Institute, 1874-5," from the Hon. the Colonial Secretary.

"Bulletin of International Meteorological Observations, taken simultaneously at 7·35 a.m., February, 1875," from Brig.-Gen. Albert J. Myer, Chief Signal Officer, War Department, Washington.

"Results of Observations in Meteorology, Terrestrial Magnatism, &c., &c.," taken at the Melbourne Observatory during the year 1873, presented to the Society by authority of Her Majesty's Government in Victoria.

"Victorian Year Book for the year 1874," from the Government Statist of Victoria.

"Catalogue of the collection of Meteorolites exhibited in the Mineral Department of the British Museum," from Professor Liversidge.

The Honorary Treasurer laid upon the table a list of members who had not paid their subscriptions for the current year.

"Supplementary Notices of Deep Sea Soundings," by the Rev. W. B. Clarke, was read by the Rev. Wm. Scott.

Professor Liversidge exhibited a specimen of binoxide of manganese taken from the red ooze by the scientific staff of H.M.S. "Challenger," from a depth of 2,600 fathoms.

Mr. H. C. Russell exhibited and explained some remarkable tide registers taken at Port Jackson and Newcastle on the 21st October and on the 6th and 7th November last. Mr. Russell also exhibited a specimen from a new photographic camera, including an angle of 110 degrees.

Professor Liversidge described and exhibited some pseudo crystallizations found on the lenses of a field-glass, which had been photographed by Mr. J. M. Smith, a student in the Laboratory of the Sydney University.

The meeting then adjourned until May, 1876.

ADDITIONS

TO THE

LIBRARY OF THE ROYAL SOCIETY OF NEW SOUTH WALES.

DONATIONS — 1875.

The names of the Donors are in *Italics.*

"Agricultural Statistics, 1874–5." From the *Government Statist of Victoria.*

"Annual Report of the South Australian Institute, 1874–5." From the *Hon. the Colonial Secretary.*

"Australian Statistics for the year 1874, with introductory Report." From the *Government Statist of Victoria.*

"Bulletin of International Meteorological Observations, taken simultaneously at 7·35 a.m., February, 1875." From *Brig.-Gen. Albert J. Meyer, Chief Signal Officer, War Department, Washington.*

"Bemærkninger i Anledning af Assessor Hjelms Foredrag: Strobemœrkninger om Bevidsthedens Væsen, af Prof. Dr. F. C. Faye. From the *Royal University, Christiana.*

"Catalogue of the collection of Meteorelites exhibited in the Mineral Department of the British Museum." From *Professor Liversidge.*

"Descriptive Papers relating to the School of Mines, Ballarat, by the Special Reporter of the *Ballarat Star.*" From the *Registrar.*

"Die Ægyptischen Denkmäler in St. Petersburg, Helsingfors, Upsala, und Copenhagen, von J. Lieblein. Two copies from the *Royal University, Christiana.*

"Forhandlinger i Vitenskaps-Selskabel, I. Christiania," Aar 1872. From the *Royal University, Christiana.*

"Forhandlinger i Vitenskaps-Selskabel, I. Christiania," Aar 1873. Andet Heft. From the *Royal University, Christiana.*

"Forhandlinger i Vitenskaps-Selskabel, I. Christiania," Aar 1873. Forsti Hefti. From the *Royal University, Christiana.*

"Fragmenta Phytographica Australia." Vols. VII and VIII. From *Baron von Müller, F.R.S.*

Grundtrækkeue i Den Ældste Norske, Proces" af Ebbe Hartzberg ved Dr. F. Brandt. From the *Royal University*, *Christiana.*

"I Anledning af Schopenhauers af det throndhimske Videnskabers-Selskab belonnede Priis-Afhandling om den frie Villies Forhold til Selvbevidstheden, ap M. J. Monrad. From the *Royal University*, *Christiana.*

"Jættigryder og Gamle Strandlinier i fast Klippe," ap S. A. Lexe. From the *Royal University*, *Christiana.*

"Memoirs of the Geological Survey of India." Vol. X, Part 2, and Vol. XI, Part 1.

"Memoirs of the Geological Survey of India," Palæontologia India; Part 1, section 10.

"Mines and Mineral Statistics of New South Wales," and "Notes of the Geological Collection of the Department of Mines." From the *Honorable John Lucas*, *Minister for Mines.*

"Neue Integrations-Methode eines 2n. Gliedrigen." Pfaffschen Problems, von Sophus Lie. From the *Royal University*, *Christiana.*

"Ninth Annual Report of the Colonial Museum and Laboratory." From the *Colonial Museum*, *Wellington.*

"Om Skuringsmærker Glacialformationem Terrasser," og Strandlinier samt Om groundfjeldets og Sparagmitfjeldets mægtighed i Norze. From the *Royal University*, *Christiana.*

"Partielle Differential Gleichungen 1. O. in denen die unbekaunte Funktion explicite vorkommt, von Sephus Lie." From the *Royal University*, *Christiana.*

"Postola Sogur," C. R. Unger. From the *Royal University*, *Christiana.*

"Proceedings of the Royal Society of London." Vol. XXIII, Nos. 157 and 158. From the *Royal Society.*

"Proceedings of the Royal Society." Vol. XXIII, Nos. 159 and 161. From the *Royal Society of London.*

"Reasons Suggestive of Mining on Physical Principles for Gold and Coal." From the Author, *J. Wood Beilby.*

"Records of the Geological Survey of India." Vol. VII, Parts 1, 2, 3, and 4. From the *Geological Museum*, *Calcutta.*

"Results of Meteorological Observations made in New South Wales, during the year 1873." From the *Government Observatory*, *Sydney.*

"Results of Observations in Meteorology and Terrestrial Magnetism," taken at the Melbourne Observatory during the year 1872, together with Abstracts from Meteorological Observations, obtained at various localities in Victoria, under the superintendence of Robert L. J. Ellery, Government Astronomer.—Vol. 1.

"Results of Observations in Meteorology, Terrestrial Magnetism, &c., &c.," taken at the Melbourne Observatory during the year 1873. Presented to the Society by authority of *Her Majesty's Government in Victoria.*

"Statistical Register of the Colony, 1874," Part 4, Law, Crime, &c.; Part 6, Production; Part 7, Accumulation.

"Statistics of the Colony of Victoria." From the *Government Statist.*

"Statistical Register of the Colony of Victoria for the year 1874;" Parts 1, 2, 3. Blue Book.

"Statistical Register of the Colony of Victoria, 1874;" Part 4, Law, Crime, &c. From the *Government Statist of Victoria.*

"Statistical Register for the Colony of Victoria, for the year 1874," part 5. Interchange from the *Government Statist of Victoria.*

"Studies from the Physiological Laboratory in the University of Cambridge." Part 1. From *Professor Liversidge.*

"Transactions and Proceedings of the New Zealand Institute 1874," Vol. VII. From the *Colonial Museum, Wellington.*

"Transactions of the Royal Society of Tasmania." Vol. I of old series; Vol. II of old series; Vol. III, Parts 1 and 2 of old series. New series, 1863 to 1868 inclusive. From the *Society.*

"Victorian Year Book," containing a digest of the Statistics of the Colony for the year 1873, by *Henry Haylyn Hayter, Government Statist of Victoria.*

"Victorian Year Book for the year 1874." From the *Government Statist of Victoria.*

"Yahresbericht des Veriens für Erdkunde zu Dresden." XI und XII. *Royal University, Christiana.*

"Zur Erklärnug des Polybius" 6, 20, von P. O. Schjott. From the Secretary to the *Royal University of Christiana.*

BOOKS PURCHASED.

"Sands' Sydney Directory."

"Australian Handbook," Gordon and Gotch.

ANNIVERSARY ADDRESS,

Delivered 12*th May*, 1875, *by the* Rev. W. B. Clarke, *M.A., F.G.S., &c., Vice-President.*

Introductory.

Gentlemen,

During several past years, it has been my privilege to be invited to address this Society on the return of its Anniversary; but, unfortunately for myself, I was prevented on the commencement of the last year by a serious illness from fulfilling the duty which was expected from me. Indeed, if I had consulted my own inclination, I would even now have preferred that my place were occupied by one of yourselves, being sensible that I am hardly yet sufficiently restored to undertake, with satisfaction to myself, the promotion of the objects for which we are again assembled. I rely, however, on that patience and courtesy which I have always experienced from my associates, to receive with kindly forbearance the remarks which I may venture to offer for your acceptance this evening.

The usual plan adopted by me on former occasions has been to preface observations of a scientific character by an allusion to matters of a more domestic kind; and I must now commence with a few words on a topic which has been introduced to notice before, but which is required to be again urged on your attention. It concerns the well-being of our Society, and bears on the question of its reputation.

Some years since we received from Authority the right to call ourselves by a more lofty title than our predecessors possessed. Foreign Societies have also honored us by their recognition, and have from time to time presented us with publications of some of their most eminent men. Strangers from neighbouring Colonies

have often inquired for our *habitat*. Where are we, as a body, to be found? Certainly, for one night in a month, for eight months in the year, we are to be found for a couple of hours either in this apartment or in some other which we have been obliged to hire. But if any one should take interest enough in us to wish to pay a visit of inquiry on any other occasion—to what House of the Society could he be directed?

> Say, on what enchanted ground
> Is our dwelling to be found?

If any one desires to profit by a reference to the published works which we are supposed to own for the good of our members, how, under present arrangements, can they be got at. Or what surveillance is there on any supposition, if the key of the "cupboard in the corner" could be procured, without an eight miles' journey to obtain it or return it, and at the risk too of not finding the custodian at home? If the liberality of our corresponding friends should increase, our bibliothecal lock-up will have to be enlarged, in order to confine as securely as before volumes condemned to an unending imprisonment. Light may be shed around us from various luminaries, but its doom has hitherto been perpetual obscurity. We are like dwellers in the desert living in tents, without a spot of earth to call our own. Every petty village in the land is aiming to obtain, by means of its School of Arts, a recognized position—a recognized habitation, and a social standing, even at public expense. But is the principal Association of a voluntary kind in New South Wales for the advancement of science and learning to be satisfied with the title it boasts of, and to be amply gratified by what is, however, without doubt a boon, the printing of the pamphlets which we call our Transactions?

Some who should aid us in our honorable endeavours to do a little good in our generation and day, but who stand aloof from us, are heard occasionally to utter a *bon mot* at our seemingly stagnant condition.

A French philosopher has said justly, "*On n'est jamais si ridicule par les qualités que l'on a que par celles que l'on affecte*

d'avoir." Now the work done by this Society is not ridiculous—but in the eyes of the inconsiderate, and there are many of that class around us, we do not make the figure which is suitable to our assumed dignity. From experience we may be convinced that all Associations of a literary or scientific kind in a new country have innumerable difficulties to contend against in their struggle for advancement. It is a hackneyed saying, "Rome was not built in a day," and it is no less true that all Societies that have attained any degree of eminence have had to struggle perhaps for years till they have gained the position to which they aspired. I am free to confess that I have wished for this Society a recognition hereafter which men may be slow to grant it now. I have desired that it may, if not immediately, yet when we all may have passed away, obtain a position in this land which may, if it never equals, at least represent here the eminent position which in other countries some one Association of a literary or scientific character has in each already attained.

I have wished that our Society should be incorporated, and that its members should not be simply annual subscribers for the purpose of an evening's amusement, but men who have nobler objects and a more resolute will to be of use to others. In that case, our elections would have a higher value, and the elected would better feel their responsibilities. You will, I hope, pardon these remarks. They have only one aim,—to awaken a more active energy than we now possess. Individually I have no interest whatever to serve in any revival or advancement of the kind. I cannot but know that before such progress shall have been accomplished "my place will no more be found." My anxiety, therefore, has nothing of selfishness in it, and my only wish is that a Society which has already contributed much useful information to the community, and which has already attained a respectable footing therein, should become the foundation on which in years to come a superstructure shall be raised to the honor and perpetual advantage of our adopted country. There are even now talents and acquirements in hundreds of our fellow-colonists sufficient to add lustre to any Association, but which are

by many withheld, from a non-appreciation of our design or from, other causes which prevent accession to our ranks. But it is impossible to believe that, before many years, the increase of population and the advancement of learning will not be accompanied by Associations that will outstep our present humble progress, and occupy that rank in social life which I am ambitious enough to wish this Society could look forward to with somewhat of parental pride. At present there has been very little in our undertakings that savours of individual and independent research. Our business has been of a somewhat local character, and perhaps in this early state of what hereafter will be of National instead of Colonial importance, we have done well to reflect a borrowed light rather than aim at shining with an effulgence of our own.

But we are in this Society altogether too insulated. We have By-laws which we have not carried into operation, and we are unconnected with other Societies in neighbouring Colonies, or even in this, which have a common object, and sometimes own a common designation.

And yet I am aware that there are papers in our Transactions by various writers which have gained for their contributors respectful attention from persons of eminence in other lands.

At a recent meeting of the Council of this Society, I was led to the expression of sentiments in accordance with the above remarks; and it is a great satisfaction to myself and, I trust, Gentlemen, to all here present, that by the active exertions of one of our leading members, whom you have elected this evening to the office of Secretary in the place of our indefatigable friend who is about to act as Treasurer, we have now advanced to the occupation of the pleasant apartment in which we commence the work of our present session.

The Society will, I hope, sanction the steps that have been taken to secure for a term this room and another, which we must modestly furnish, so that our work may be carried on more successfully than hitherto.

There are some other considerations which suggest themselves as to the publication of discussions that occasionally follow the

reading of papers,—the compilation of a Catalogue of books and pamphlets accessible to members generally, and other collateral matters which may properly be left in the hands of the Council and Secretaries, to whom, however, I take the liberty of observing that all donations should be officially acknowledged, especially as questions have been asked as to such omissions. In venturing to give utterance to the preceding remarks, I disclaim all intention of forgetting the past services of the gentlemen who have voluntarily undertaken the official work of the Society, and, if I may be allowed, I would now convey the united thanks of the contributors, to the outgoing Secretaries, one of whom has for a considerable period so carefully superintended the passage of their papers through the press.

Finances.

In the absence of the Treasurer, who is in Europe, I may venture to state a very close approximation to the present state of our finances, of which an account is laid on the table duly audited.

The balance in the Bank on 30th April, 1874, was	£94	1	4
Subscriptions and entrance fees since then, up to this date	£139	14	0
Making a total of	£233	15	4
which would be more if all our members had paid up their subscriptions.			
The expenses of last year amounted to	£143	15	4
Leaving still a Bank balance of	£90	0	0
In this account are included the salary of the Assistant Secretary, up to 31st December, 1874, amounting to	£40	0	0
and the cost of the *Conversazione* in 1874 ...	£60	0	0

It will be seen that the expenses last year were greater than our receipts. Husbanding our resources this year, we shall be able to meet the expenses that will ensue on the present occu-

pation of our apartments, and the other incidental charges that will necessarily be involved; and, if the Government would considerately assist us in the matter of rent, or in any other acceptable way, we might still further advance a step or two towards our desired end.

Present State and Progress of the Society.

The relative number of members increased from 116 in the year 1873–4 to 155 in the year just closed. Of these, *three* are life members. We have lost four by death since I last addressed you—one of whom was Alexander Berry, Esq., the oldest member of our body, who dated his connection with the original Philosophical Society from the year 1821, just fifty-four years ago, and was gathered to his fathers at the patriarchal age of ninety-two. The three others were Staff Commander Gowlland, R.N., Thomas Barker, and A. H. Richardson, Esqs.

The death of the former was an event of painful interest to the community. Having but recently returned from England, where he had gained for his services in the Navy his promotion to the rank of Staff Commander, he was employed in the survey of our harbour, and by an unexpected roller from the heads was, with one of his assistants, swamped and drowned within a short distance from the shore, with as much suddenness as if he had been slain in battle. His previous services in connection with the great Eclipse of the Sun, in 1872, and in searching for the survivors of the unfortunate New Guinea expedition, had given him a double claim to our respect. Both these events were alluded to in my address of 1872. But from his official reputation, and the notes and drawings left behind him of scenes visited by him in various parts of the globe, we may conclude that by Captain Gowlland's death we have lost a friend whose acquirements and accomplishments made him an ornament to our Society, as well as to the Naval and Colonial Services to which he belonged.

The following lists record the work done by the Society during the last two sessions :—

PAPERS READ, 1873–74.

1. Anniversary Address. By the Rev. W. B. Clarke, M.A., Vice-President.
2. Appendix to the Anniversary Address.
3. On the solution of certain Geodesic Problems. By Martin Gardiner, Esq., C.E.
4. Local particulars of the Transit of Venus. By H. C. Russell, Esq., M.A.
5. Note on the Bingera Diamond District. By Archibald Liversidge, Esq.
6. On our Coal and Coal Ports. By James Manning, Esq.
7. Appendix to " On our Coal and Coal Ports."
8. On our Coal and Coal Ports. No. 2. By James Manning, Esq.
9. The Mammals of Australia and their Classification. Part 1.—Ornithodelphia and Didelphia. By Gerard Krefft, Esq.
10. On Geodesic Investigations. By Martin Gardiner, Esq., C.E.

PAPERS READ, 1874–75.

1. On Duplex Telegraphy. By E. C. Cracknell, Esq.
2. On Hospital Accommodation. By Alfred Roberts, Esq.
3. On the Criminal Statistics of New South Wales. By Christopher Rolleston, Esq.
4. Description of Eleven new Species of Terrestrial and Marine Shells from the North-east Coast of Australia. By John Brazier, Esq., C.M.R.Z.S.
5. On the Treatment of Iron Pyrites. By G. Latta, Esq. Read by H. A. Thompson, Esq.
6. Iron and Coal Deposits at Wallerawang. By Professor Liversidge. Read by Professor Smith.
7. Nickel Minerals from New Caledonia. By Professor Liversidge. Read by Professor Smith.
8. Sydney Water Supply by Gravitation. By James Manning, Esq.
9. Results of Observations of the late Transit of Venus. By H. C. Russell, Esq., M.A., Government Astronomer.
10. Results of Observations of the late Transit of Venus, at Eden. By the Rev. William Scott, M.A., Warden of St. Paul's College. Read by H. C. Russell, Esq., M.A.

SCIENTIFIC RESEARCHES ON BOARD H.M.S. " CHALLENGER."

IT will be in the recollection of most of us, that the session of the year 1874 commenced with a *Conversazione* to which numerous friends were invited, to witness the experiments of my learned colleague Professor Smith, and to inspect the instruments for deep sea sounding exhibited by Captain Nares, R.N., of H.M.S. "Challenger," together with specimens of the

marvellous creatures brought up from great depths by those contrivances; and the diagrams illustrating the wonderful features of the bottom of the ocean. A request was made by me to Professor Wyville Thompson, for a personal explanation of the phenomena discovered by him; but in a courteous reply he informed me that he was unable to gratify us by consent, as he would be absent on the evening of our meeting on an excursion in Queensland in search of specimens of the *Ceratodus Forsteri.* We were thus deprived of the instruction which an address from that most skilful naturalist could not fail to have afforded us. On his return he showed me, on board the "Challenger," the fruits of his journey; and at the same time teeth of that extraordinary amphibian which, though breathing through lungs and feeding on vegetable matter, is still a fish,—which teeth were in a fossil condition, implying that *Ceratodus* must have existed in Australia long anterior to the present epoch, as we know that other species did so long ago as the Triassic period, as shown by teeth of identical structure and generally similar form in the Trias of Austcliff, in England, and at Maledi in India, where teeth were discovered during the geological survey of that country under the superintendence of Dr. Oldham. This singular ally of the *Lepidosiren* is conclusively shown by Dr. Günther of the British Museum to have had even a higher lineage than has been mentioned, and to belong to the same classification as certain fishes of the Devonian epoch, proving an antiquity of enormous age. When Mr. Forster brought down this creature for the purpose of scientific examination, he perhaps little anticipated that his name would go down to a distant posterity in association with a creature that dates its family descent from the dark ages of pristine existence, during the dominion of the Devonian and Carboniferous æons.

Nor ought it be otherwise than a matter of some congratulation that, considering how many things in Australia are first notified in Europe, so interesting a discovery should have been submitted to first examination in our own Colonial Museum, several of whose Trustees saw and recognized its genus, and by

the Curator of which institution it was first described. Dr. Günther, in his more elaborate description, does full justice to the brief notice of the *Ceratodus* and the correctness of the alliance to *Lepidosiren*, pointed out in that notice by Mr. Krefft who by good management obtained it for the Museum. The importance of this genus, of which another species, *C. Miolepis*, has been found since, resembling in its teeth one of the Secondary forms, may be gathered from the following remark by Dr. Günther :—"In *Ceratodus* we have now found a genus which, as far as evidence goes, persisted unchanged from the Mesozoic era; and in the *Sirenidæ*, a family the nearest ally of which lived in the Palæozoic epochs." [Phil. Trans., Part II, 1871, p. 561.]

It is an extraordinary fact that we have living in Australia numerous species belonging to the vegetable and animal kingdoms which represent genera of vast antiquity in the geological scale of life, and recent investigations have corrected some of the errors which have prevailed. Till recently the *Ceratodus* was considered to be a shark; and Mr. Tate, who has published an excellent paper on the Secondary fossils of South Africa (Q. J., G. S., Feb., 1867), speaking of the Order *Cycadaceæ* during Jurassic times, says the Order has only continued to exist in South Africa, forgetting that it has representatives both recent and fossil in Australia.

Among the curious things shown to me on board the "Challenger," there were representatives of *Pentacrinus* and other Cretaceous genera, as well as a variety of novel organisms, for the descriptions of which we must wait till the future publications of Professor Thomson shall have placed his illustrations of them before the world.

The diagrams exhibited in 1874 to this Society were confined to the Atlantic, as the "Challenger" had not then completed its work in the Pacific, nor had the portion belonging to the ocean space between Sydney and New Zealand (in which we are all interested in relation to submarine communication) been then sounded in its greater depths. The view which was formed of

the bottom of the Northern Atlantic, as described in that beautiful work "The Depths of the Sea," has been confirmed by more recent discoveries on the present voyage, and there is little doubt that the cretaceous deposits are still going on almost as they were during the chalk era.

But the soundings that have been made in the Atlantic have led to further conclusions. They have made known the variety, densities, temperatures, and depths of the sea currents and strata of water between Europe, America, and Africa, and have shown the surprising fact that, as far north as the Bay of Biscay it is to an *Antarctic* current, and not as generally believed to an Arctic one, that the deep water there and under the Equator is colder than that of the Northern Atlantic, so much nearer to the Arctic regions. The Arctic current is said to be cut off from the Antarctic. The cold Antarctic acts like the Gulf Stream in expanding and dying out; and is found, where it enters the North Atlantic, to have a thickness of 700 fathoms. Its breadth is stated to be 500 miles. (Report of 15th December.) The coldest water was obtained in the South Atlantic section, close to the American coast, where it was 33·1° F. at a depth of 2,150 fathoms.

At 300 miles west of the Cape of Good Hope the water is colder at all depths down to 1,500 fathoms, continuing nearly equable to the bottom, which is half a degree warmer than at the Equator. The warm Agulhas current was found eighty miles further west, and the temperature was 60° F., or 4° F. higher than to the east, the Table Bay water being much colder than that in Simon's Bay.

An interesting circumstance was noticed in the latter bay; with a S.E. wind the temperature was the same as outside the land (in October), viz., 62° to 64° F., but a N.W. gale drove this water out of the bay. It was replaced in six hours by water at a temperature of 51°. So soon as the N.W. wind ceased, the water rose to the temperature of the returning Agulhas stream. The surface temperature of 51° was colder than any found on the

run from Brazil, except at a depth of fifty fathoms; the lowest surface temperature being 54° F.

On the diagrams which were exhibited at the *Conversazione*, we saw also depicted the extraordinary way in which the islands of the Atlantic, such as Madeira, the Azores, Teneriffe, Bermuda, St. Paul's Rock (the most striking of all), St. Thomas's (in the West Indies), and Fernando de Noronha, as well as the Cape of Good Hope, rise from the sea-bottom at a very small angle through the ocean which, at a short distance is of enormous depth. The escarpments are almost perpendicular. For example, the base of Bermuda, at a depth of from 2,500 to 2,650 fathoms, is but 120 miles broad; whilst the base of Madeira is distant only 90 miles from that of the Azores at the same depth of 2,656 fathoms; the temperature being—at Bermuda 35°, at Madeira 35·7°, and at the Azores 35·3°. Off the Cape of Good Hope, at a distance of 35 miles, the temperature was 32·9° at a depth of 2,325 fathoms. The base of St. Vincent and St. Jago Islands (which are separate spires or horns rising from the base at a distance of 110 miles) is only 300 miles wide at a depth of 2,100 fathoms. The actual base of St. Paul's Rock, a mere speck on the surface, has a base of 115 miles at a depth of 1,900 fathoms, the surface temperature being 75°, and the bottom 35·8°.

Fernando Noronha has a base of only 45 miles at a depth of 2,150 fathoms; the temperature of the water at that depth (236m. S. of the Equator) being only about 33°, whilst at a depth on one side of 2,475 fathoms the temperature was 32·4° (just above freezing-point), and on the other or Brazil side the temperature was 33·2° at a depth of 2,275 fathoms. The temperature of 32·2° was also that of the ocean at a depth of 2,550 fathoms, between the Cape of Good Hope and Tristan d'Acunha, in latitude 37° 6′ S., 710 miles from the former. These examples are taken from the diagrams; but it is to be observed that, if they had been drawn to equal scales, the actual elevations and breadths of the basis would not have shown the same differences. Then the bottom of the Atlantic would have been represented by a line of apparently small undulations between the islands, and

would have more nearly realized the notion that has been expressed by previous observers, that one might drive a coach along it.

In the Reports to the Admiralty, which, by the favour of Captain Nares, I had the pleasure of reading, are mentioned several facts which appear to me too important to be passed over.

From previous researches in laying the cable to America, it was known that the bottom of the Atlantic was in wide areas covered with what the navigators called *ooze*. Captain Nares states that a newer deposit was found at about two-thirds of the distance between the Canary Islands and the West Indies, and at a depth of 3,150 fathoms this deposit of chocolate-coloured clay extended for about 350 miles to the east and west of the deep channel or hollow, without the usual characteristics of Atlantic ooze, and with but little life of any kind. At about three-fifths across, 1,000 miles east of the West Indies, a depth of 1,900 fathoms only was obtained; 2,000 fathoms only extending for at least 180 miles; so that here was a rise instead of a hollow, indicating some geological change, since at 2,025 fathoms a little to the eastward "the sounding rod was filled with decomposed rock." The temperature of the bottom at all depths, except at the sounding of 1,525 fathoms near the Canary Islands, was remarkably uniform, ranging from 35·6° F. on the African to 34·9° F. on the American side of the Atlantic. (Report of 16th March, 1873.)

The Gulf Stream also has been subjected to cross-examination, and its source, course, and habit have been partially discovered. Previous researches on two occasions in the North Sea, and in laying the cable to America, had resulted in certain determinations respecting the warm surface of the north-eastern prolongation of the Gulf Stream as far even as the Arctic Ocean itself, under which was found a cold current from that ocean. A temperature of 49° F. is found to exist nearly all across the Atlantic from E. to W. at a uniform depth of about 380 fathoms. The water above gradually increases, and below gradually decreases in temperature.

The following extract is worth notice :—" The heat-giving properties of the Equatorial and north-east Trade current, carrying as they do, a continuous body of warmed water towards the Caribbean Sea can be traced by rise of temperature of the whole body of water at Sombrero, and afterwards to all the stations on the North Atlantic, but most readily so by the widening of the Isotherms, about 62° F. between America and the Azores, forming an immense reservoir of warmed water 1,000 feet thick, and at least 2,000,000 of square miles in extent. This change of temperature or disturbance is greater and nearer to the surface on the western side of the Atlantic, the nearest point to the source of the current than at the eastern side, where it slowly but gradually expands itself, sinking as it expires."

The Gulf Stream being only superficial, extends 100 fathoms down, and underneath it is the cold Labrador current running southward on the American coast; but the Equatorial stratum of warm water expands an enormous store of heat 3,250 miles from the Gulf Stream, retaining a steady temperature, and stretching to the coasts of Europe north of the Azores. The same warm stratum extends from 260 miles north of St. Thomas's to the Gulf Stream, a distance of 1,000 miles. The origin of this immense body of warm water is not yet known. It is no doubt the cause of the moderate temperature of the south and south-west coast of England and the West of Ireland, just as our Sydney winters are milder from the influence of the Pacific Stream from the north-east. It is said that the Gulf Stream may be traced to Spitzbergen.

In his Report of 15th September, Captain Nares mentions that at Porto Rayo, in Saint Jago, one of the Cape Verde Islands, a red coral similar to that in the Mediterranean was found growing at 80 fathoms of water at 52° of temperature, which is that of the Mediterranean banks, and he adds, " We have never found that temperature at the same depth further north."

In the year 1846, a paper of mine on the island of Lafu was read before the Geological Society of London (Q.J.G.S. III, 63), in which I mentioned the fact that certain corals grew in Port

Jackson in shallow water of a temperature below that then supposed necessary for such growth, viz., 60° to 70°.

Mr. Couthouy, of Boston, U.S., states that the *Astreas* flourish best in water not over 78° F. His companion in the scientific corps of the U.S. Ex. Ex. (Professor J. C. Dana) shows that reef-forming corals range in water between 66° and 85° F. Captain Nares, if I remember rightly, shows that some corals will grow in water at a temperature of less than 30° F. The value of such inquiries, in a geological point of view, has been shown by Dr. Duncan, Q.J.G.S. vol. xxvi, 1870.

It may not be of much importance now to repeat the soundings given in the Reports, of the various depths at which red clay, grey mud, shells, grey ooze, and *Globigerina* ooze was found; but from Captain Nares's tables I have calculated that the latter has a mean depth in the Atlantic of 1,957 fathoms, or 11,742 feet, at a mean temperature of 35·38°. The occurrence of delicate Pentacrinites and other living beings at great depths refutes, however, the notion that pressure prevents life, for the pressure upon these creatures was so great as to crush iron. We may ask whether the cause of resistance to the pressure is the fact that these delicate animals are themselves pervious to water, or, as in the case of *Globigerinæ*, because they are also globular. At a depth of 2,500 fathoms the pressure amounts to eight tons to the square inch. Near St. Thomas's Island the sea bottom is 3,875 fathoms below the surface. We may ask again, how can creatures whose bodily surface has only one inch in extent bear even one-fourth of such pressure unless the pressure from within is equal?

I cannot resist the temptation of quoting here a passage or two from another authority on the present topic. Dr. Wallich who was naturalist in the Expedition of 1860, under Sir L. M'Clintoch, on board the "Bull Dog," surveying the telegraph route between Great Britain and America, published for private circulation some "Notes on the Presence of Animal Life at vast depths in the Sea," and from them I take the following statements :—"On two occasions living specimens of *Serpula* were obtained. One at a moderate depth, the other at 680 fathoms,

and in conjunction with a living *Spirorbis*. Other free Annelids and two Amphipod Crustaceans, were also taken alive at 445 fathoms.

"But by far the most interesting discovery remains to be noticed. In sounding not quite mid-way between Cape Farewell and Rockall, in 1,260 fathoms, whilst the sounding apparatus brought up an ample specimen, of coarse gritty looking matter, consisting of about 95 per cent. of clean *Globigerina* shells, a number of starfishes, belonging to the genus *Ophiocoma*, came up adherent to the lowest 50 fathoms of the deep sea-line employed. The quantity of line had been paid out in excess of the depth which was determined by a different operation; and it must, therefore, have rested on the bottom for a few minutes, so as to admit of the starfishes attaching themselves to it. On reaching the surface, and for upwards of a quarter of an hour afterwards, they continued to move about energetically.

"One very perfect specimen, which had fixed itself close to the extreme end of the line, and was still convulsively grasping it with its long spinous arms, was secured *in situ* on the rope, and consigned to immortality in a bottle of spirits.

"Here then is a fresh starting point in the Natural History of the sea. At a depth of two miles below the surface, where the pressure must amount to at least a ton and a half on the square inch—where it is difficult to believe that the most attenuated ray of light can penetrate—we find a highly organized species of radiate animal living, and evidently flourishing,—its red and light-pink coloured tints as clear and brilliant as seen in its congeners inhabiting the shallow waters where the sun's rays penetrate freely.

"Arguing from preconceived ideas, we should certainly not expect to find in these deep sea starfishes the same internal organization as is to be met with in shoal-water forms; or that the circulating fluid, no matter how simply composed, could traverse the delicate membranes possessed by them. Unlike some of the higher families of the Radiata, the *Ophiocomæ* do not

boast of protusile suckers and the complicated muscular and vascular systems associated with such organs. But it is nevertheless evident that (in defiance of the obstacles enumerated) *circulation of sea-water*, if of no special fluid, over the peritoneal lining of their cavities, digestion, assimilation, and reproduction are carried on unrestrictedly, in addition to the somewhat simpler but no less essential operations of locomotion and capture of food.

"The *Ophiuridæ* are strictly carnivorous. The specimen dissected by me was found to differ in no respect, as regards internal anatomy, from the species inhabiting shallow water. In the alimentary cavity numerous *Globigerina* shells occurred more or less completely freed of their soft contents.

"The distance of the position at which they were obtained from the nearest land of Greenland, namely, Cape Farewell, is 500 miles. From the nearest point of Iceland, namely, the Blinde Skier rocks, 250 miles. It is necessary to mention this, lest it be deemed possible that the starfishes could have been drifted by currents or borne by any other means from any other country.

"In the *Ophiuridæ* motion is performed altogether by the spine-covered arms, from which they derive their name of 'Spinigrada.' The spines are all articulated to the arms, and, by means of the rowing-like motion of which they are susceptible, enable the creature to travel along its course,—the weight of the body and arms chiefly made up of calcareous matter, entirely precluding it from floating, or even raising itself off the bottom.

"All former opinions as to the limits of life in the deep sea must give place under such a startling fact. * * * * * We may, therefore, look forward to no very distant period, to the discovery of a new submarine fauna, frequenting the deeper fastnesses of the ocean, which, whilst furnishing a new field for those who are content to seek after novelty, shall also throw a gleam of light on the Geology and Palæontology of the globe." (p. 25.)

Again—"One of the most powerful collateral proofs of the *Globigerinæ* being able to live at great depths is derived from the

discovery of creatures removed far above them in the scale of organization, the vitality of which remained unimpaired for some time after they had been brought up from a depth of nearly 1,300 fathoms * * *

"They (the *Ophiuridæ*) nevertheless do exist there and were found at a point where the *Globigerinæ* constitute as much as 95 per cent. of the deposit on which they rest. (p. 11.) * * *

"The smallest *Globigerina* shell met with by me in this material measured $\frac{1}{600}$th of an inch in diameter, and contained but two chambers, the size of the free 'coccoliths' being $\frac{1}{3000}$th of an inch in diameter, or five times smaller.

"It is worthy of record that the occurrence of *Globigerinæ* in two soundings between Cape Farewell and Rockall, in 1,260 and 1,607 fathoms, the one containing 95 per cent., the other 98 per cent. of clean shells, with hardly a trace of any other organic or inorganic matter, affords an almost direct proof that their respence is not due to drift or deposition by currents." (p. 15.)

Two questions suggest themselves to me from the above discussion:—(1.) Assuming that the *Globigerina* ooze is a deposit of very similar character to that of the old cretaceous formation, was the ancient chalk deposited in the same way in cold water and in a very deep sea? (2.) And in those days was there any ocean stream, like the modern Gulf Stream, which Dr. Wallich (p. 19) associates in an intimate manner with *Globigerinæ*, "when in any quantity in the deep sea deposits;" quoting the case of the ocean bottom "between Ireland and Newfoundland," and "between the Faroe Islands and Iceland?"

Some other extraordinary circumstances are connected with the sea bottom of the Atlantic. In a paper by Professor Wyville Thomson, entitled "Preliminary Notes on the Nature of the Sea bottom, procured by the soundings of H.M.S. 'Challenger' in the Southern Sea, in the early part of 1874," and read before the Royal Society of England on 26th November last, we find some remarkable facts, which can only be briefly alluded to here.

Five distinct conditions of the sea bottom were ascertained, without reckoning as one the detritus of shallow soundings near land.

All the organisms at the bottom in certain depths were dead, and the *Globigerina ooze* consisted of but little else. It appears that the living Foraminifera float on the surface, or at some intermediate depth, but subside to the bottom after death, and the Professor has satisfied himself of that fact. From all seas, from the Equator to the Polar ice, the tow net contains *Globigerinæ*, but they are smaller as the distance increases from the equator. The living *Globigerinæ* differ from the dead inasmuch as the former are ornamented by flexible calcareous spines, springing from the deep hexagonal borders of the pores. "The spines radiate symmetrically from the direction of the centre of each chamber of the shell, and the sheaves of long transparent needles crossing each other in different directions have a very beautiful effect." The smaller chambers are filled with an orange yellow sarcode, or a portion of it adhering to one side. No structure was detected in that sarcode. The spines are so delicate that they break off with the slightest touch, and are never found at the bottom, even when it is shallow. *Orbulina universa* is another of the Foraminifera which is sometimes also found with nearly empty chambers. It is supposed by some writers to be the young of *Globigerina*. The two genera, however, do not always occur together on the surface, but both are more fully developed and abundant in the warmer seas. South of Kerguelen Island, neither *Orbulina* nor *Pulvinulina* (which has two species) was detected. Other minute organisms occur with the former. In the intertropical regions the bulk of the ooze is made up of shells and fragments of shells of the above Foraminifera, yet in some cases at least 20 per cent. of a fine granular calcareous matter cements and fills the shells. This, under the microscope, comes out as "coccoliths" and "rhabdoliths."

These last-named are the armatures of certain spherical bodies—cocco spheres and rhabdo spheres—which are surface inhabitants of the warmer seas, and are considered to belong to the *Algæ*. They

also sink to the bottom, but are not found much south of Prince Edward Island, north to the west of Faroe.

The "Globigerina ooze" is limited to certain depths—about 2,250 fathoms. Below 2,500 fathoms the calcareous formation passes to a red clay, which is a silicate of the red oxide of iron and alumina. The shells in the ooze gradually lose their distinctness, become brownish, and more and more mixed with red powder till the lime disappears. Between the two substances comes in the "grey ooze," which has an intermediate character. The proportion of the two extreme deposits is 1,900 miles of red clay to 720 miles of *Globigerina* ooze. The mean maximum depth of the latter is 2,250 fathoms, that of grey ooze 2,400, of the red clay 2,700 fathoms. Wherever the depth increases from about 2,200 to 2,600 fathoms, the modern chalk formation of the Atlantic and of other oceans passes into red clay.

What is the origin of this red clay? Though pelagic mollusca swarm in the mid-Atlantic, their shells are found in the *Globigerina* ooze, but never in the red clay; and the facts observed show that they probably have been removed from the latter in some way after death. The conclusion come to is that the "red clay" is not anything from without, but that the lime, which forms 98 per cent. of the *Globigerina* ooze, is removed from it, and the red clay is considered to be the "essentially insoluble residue"—the ash, as it were, of the calcareous organisms of the ooze after the calcareous matter has been removed. A mixture of the shells forming the ooze from near St. Thomas's Island was submitted to the action of weak acid, and after the lime was removed there was left about 1 per cent. of reddish mud, consisting of alumina, silica, and the red oxide of iron. This experiment has often been repeated with the same result.

On the 13th March the trawl brought up a large quantity of nodules of the peroxide of manganese, and they appear generally in the "red clay," never in the "ooze"; but no sooner had the removal of the carbonate of lime commenced than small black grains became apparent and represented the nodules common in the red clay when the manganese is in very considerable propor-

tion. This manganese is peculiarly set free, like the iron, by the decomposition of the organic bodies and tests. In some Algæ it exists to the amount of 4 per cent.

A shark's tooth is sometimes replaced by the manganese and a piece of pumice or a pebble is coated with a fine black mammillated layer.*

Professor Wyville Thomson remarks that, though the red clay is unfavourable to life, it is possible at all depths, and diminishes below 1,500 fathoms. Moreover, the free carbonic acid found in all sea water is rather in excess in the greater depths; and it is possible that the sea water may attack the sinking shells, and begin to decompose them in their slow descent to the bottom through a passage of a half-mile or so of water of increasing density. Nevertheless *Holothurids* and *Bryozoa* were sometimes drawn up from great depths, and about 150 miles from Sombrero very well-marked red mud which did not effervesce with hydrochloric acid held imbedded "tubes of a tube-building *Annelid*, several of which were from three to nine inches long, containing the worm still living."

The conclusion drawn by the Professor is, that as the chalk, so the red clay may be under certain circumstances an organic product, and that "an area of the surface of the globe, which we have shown to be of vast extent, is being covered by such a deposit at the present day."

He also suggests that "the fine, smooth homogeneous clays and schists, poor in fossils, but showing worm tubes and tracks, and such things as *Oldhamia*, siliceous Sponges, and thin-shelled peculiar Shrimps (belonging to the oldest known geological sediments) may be organic formations like the red clay of the Atlantic and Southern Sea—accumulations of the insoluble ashes of shelled creatures."

* This deposit of manganese, of which I saw specimens on board the "Challenger," is very common on pebbles and quartz in some of the alluvial auriferous deposits on the Cudgegong, and is also seen on smooth planes of granite, porphyry, sandstone, &c., &c., in the form of Dendrites.

Besides the red clay, there is sometimes a fine cream-coloured paste, which scarcely effervesced with acids, and dried into a light impalpable white powder. This turned out to consist almost entirely of the frustules of *Diatoms.* Mixed with them were other curious organisms.

Near the edge of the Antarctic ice-pack were found pebbles of quartz and felspar, and small fragments of mica slate, chlorite slate, clay slate, gneiss, and granite in pure sand and greyish mud, believed to be the result of the melting of ice. As no such materials were seen *on* the icebergs, they must have come from the base, which melts away first when in contact with the rising temperature of the water.

I have recently obtained some data respecting our part of the Pacific.

Between Kerguelen Island and Melbourne, the *Globigerina* ooze had a depth of 1,800 to 2,150 fathoms, and the red clay a depth of 2,600, and about 30 miles eastwards from Montagu Island, on our New South Wales coast, the 100 fathom ledge was found to go down precipitously to 2,200 fathoms.

Peschel's conjecture that New Zealand, New Caledonia, and Australia formed one continent, with an African form, receives some support from the nature of the coasts.

I may remark that many years ago, observing that the land, back of the Illawarra, fell in a precipitous escarpment to the level of that district, which was succeeded by indications of further sub-volcanic escarpments, I requested Admiral (then Captain) Erskine, R.N., to be so good on his next passage south to sound off Kiama, which he obligingly did, and informed me that there was a great fall, as I had conjectured, at about 25 to 30 miles off the land.

From a letter written by Dr. Von Willemoes-Suhm to Dr. Petermann, dated Cook's Straits, 25th June, 1874, we learn that the depth to the eastward of Sydney increased rapidly to 80, 290, 600, and 1,000 fathoms. On the 13th June they had returned off he Australian coast (in 34° 19′ S. and 151° 31′ E.), and in 410

fathoms dredged up a "representative of the fossil genus *Porocidaris*" (this is an Echinoderm, having four known fossil species—one Jurassic, two Nummulitic, and one Miocene); with another retaining its lustre, allied to *Calveria*.

On the 17th June, in 34° 50′ S. and 155° 28′ E., from a depth of 2,000 fathoms, were dredged a *Bryozoa*, a *Crangon*, and spiculæ of *Hyalæa*.

18th June, 2,625 fathoms were sounded; next day, 2,600 fathoms, 720 miles N.W. of Cape Farewell in New Zealand. 20th June, in 37° 1′ S. and 160° 42′ E., 2,600 fathoms. 21st June, in 37° 58′ S. and 163° 39′ E., 2,000 fathoms. Here began the long slope upwards to New Zealand. 22nd June, in 37° 58′ S. and 166° 19′ E., the depth was reduced to 1,100; and on 23rd, in 38° 52′ S. and 171° 48′ E. to 275 fathoms. Here were dredged two specimens of *Nephrops*, much resembling many ancient crabs. On 24th June, in 39° 32′ S. and 171° 48′ E., in 150 fathoms, a decapod (*Ibacus*) and yesterday's crabs were dredged. 25th June, off Cape Farewell, in 39 fathoms.

From the above is deduced:

1. That the south-east coast of Australia has a precipitous fall.
2. That New Zealand is separated from it by a channel which has a depth of 15,600 feet.
3. That the latter rises gradually from the sea.

Another set of soundings was obtained, between Sydney and Cook's Strait, at 17 miles from the land on the Australian side. The 100 fathoms ledge fell to 2,100 fathoms at 57 miles distant, about 1 in 20, which is less abrupt than is the fall southward of Twofold Bay, which is 1 in 6. The bottom of soft ooze then sloped down to a depth of 2,000 fathoms, at 240 miles from the coast, the temperature being 33° F., the same conditions continuing for 140 miles. From this depth there is a gentle upward slope of soft ooze for 400 miles, until soundings were obtained in 1,100 fathoms, at 780 miles from Sydney, and 335 miles from the entrance to Cook's Strait. Between that position and New Zealand, soundings below 400 fathoms with hard bottom were

obtained. The most westerly in 275 fathoms was 200 miles from the land, and 125 miles eastward of the 1,100 fathoms sounding. The shoal water, Captain Nares says, extends probably 100 miles further to westward, giving a total breadth of 300 miles for the shallow water. The bottom was hard and smooth. The shallow water is supposed to extend to the somewhat similar banks to the westward of the north-west cape of New Zealand ; but at the south-west extremity of the middle island, which is the nearest point of land to Australia, there is every probability that the deep water extends to within a short distance of the New Zealand coast. (*Captain Nares to Sir Hercules Robinson*, 2*nd July*, 1874.)

My own view has been long ago expressed that the older rocks of New Holland and New Zealand form parallel anticlinals bordering the synclinal depression of the ocean, and this is nearly the same as Peschel's view. Though this depression descends to a depth rather more than the height of Mount Cook, there is no reason why, if denudation had not carried away the more level formations, a passage could not have existed across what would then have been a connected country, or a chain of islands. And as Sir James Ross had soundings 280 miles N. 80° W. from the Three Kings, there is a sort of prolongation of the north end of New Zealand towards Queensland, with intermediate high islands such as Howe and Norfolk and others, and therefore the inference ought to be allowed consideration. This was the ground on which believing the femur of a bird which was found at Peak Downs, at a considerable depth under drift gravel and resting on granite, to belong to *Dinornis*, (as Mr. Krefft also believed after comparing the bones with the similar bones of *Dinornis* in the Museum), I put such an inference in a letter to the *Geological Magazine* (vi. 383), and again in my Address to this Society in 1870, as an argument for the former connection of the two countries, which have since been separated by a synclinal curve of the rock formations forming the sea channel between them. Professor Owen, however, in obedience to the law he has enunciated as to the occurrence of animals of the same character

in each country between its present and last geological inhabitants, has described it as a *Dromornis*, and Dr. Haast in New Zealand has followed this view in his Address as President of the Philosophical Institute of Canterbury in 1874.

As I have long had in my own collection bones of a Struthioid bird, from the Coodradigbee caverns, it is not unlikely that the femur in question belonged to a bird once indigenous to Australia alone, where the Emu still is found.

But whether or not there has been in late times any possible open air connection between New Zealand and Australia, the mystery is as great as ever respecting the occurrence of wingless birds, or such as cannot fly, in so many Islands of the Pacific.

It does not appear to me that the fact can be explained by a theory of development, and the idea of individual creations in so many separate islands will be rejected by those who believe in centres of creation having a wide range. Not having yet received a copy of Professor Owen's paper on *Dromornis*, and not being fully acquainted with some other local circumstances, I nevertheless accept the determination of the great comparative anatomist, and recall the term *Dinornis*, awaiting further discoveries.

From New Zealand to Cape York there is a gap in my notes relating to the voyage of the "Challenger"; but it appears that from the latter place to Hongkong the soundings showed that the sea bottom consists of a series of sunken lakes, the deepest portions being surrounded by a shallower rim. The water above the rim can circulate freely, and belongs to the cold Antarctic current, the temperature of which may vary according to depth of rim, but the deep parts not being able to rise retain a fixed temperature; thus east of Torres Strait, the rim 1,300 fathoms deep encloses a lake 2,450 fathoms deep, the water of which remains at 35° F. The Banda sea is cut off at 900 fathoms, though it is 2,800 fathoms deep; the Celebes Sea is 2,600 fathoms deep, and is shut in by a cup, the rim of which is only 400 fathoms below the surface, the water below having a temperature of 50° F. The Molucca passage is open to the depth of 1,200, and

the China sea to 1,050 fathoms, the greatest depths attained there.

Advices have, however, been received from the "Challenger," dated 23rd March, 1875, giving an account of the deepest sounding, made from that ship on that day, when in latitude 11° 24′ N., and longitude 145° 16′ E., by aid of a weight of 4 cwt., the enormous depth of 4,450 fathoms or 26,700 feet was reached. This was preceded on the same day by an attempt to reach the bottom with 3 cwt., on which occasion the glass of three of the thermometers was crushed into fine powder. But the bottom must in some way have been reached, as the tube brought up traces of red clay. The other thermometer had recorded the temperature as 35·5° F. The spot indicated appears to be nearly north, not far from the meridian of the S.E. point of New Guinea, which is also that of the Barrier Reef of Australia, where the east coast begins to trend north-westerly from near Cape Flattery to Cape Melville. Another account makes the depth 4,475 fathoms.

Before this New Guinea had been visited, but the soundings of that island are at present unknown to me.

At the date of the communication just referred to, the "Challenger" was about to proceed to Japan. In the absence of other data, we may notice the soundings of Captain Belknap, of the U.S. steamer "Tuscarora," who reported from Japan, 26th June, 1874, that about 1,000 miles E. by S. of Kingharan Bay, on the coast of Japan, the lead sunk to a depth of 3,427 fathoms, going still deeper at 45 miles further, viz., to 4,643 fathoms.

Parallel to the Island of Yesso, at the edge of the Japan stream, a depth of 3,493 fathoms was reached; 48 miles further, 3,587 and 3,307 fathoms, and an extra depth of nearly a statute mile was reached in the bed of the stream. Two other casts showed 4,411 and 4,655 fathoms.

During my conversation with officers on board the "Challenger," I remarked the surprise expressed that no one had yet made out the history of the Australian current which sets along our shores,

and which they, as well as myself, believed to be a true "Gulf stream," in temperature, range, depth probably, and its habit of spreading over the surface, as well as being affected at its edges by powerful winds.

There ought to be some data already available towards its history; and I do not doubt that others have done what I have frequently done during coasting passages along our east coast, viz., have taken the temperature of the surface water of the ocean, comparing it with that of the air. Our Treasurer, the Colonial Astronomer, who is absent in Europe, must have many records of changes of temperature and other phenomena connected with gales of wind, *earthquake waves*, *rollers*, *&c.*; and it would be possible to obtain other data as to direction and breadth and velocity of the current from the logs of vessels constantly navigating up and down the coast, if such incidents are recorded in the log-books, which, when collected and arranged, would form the basis of a very useful communication to this Society.

Lifu Island.

Incidentally I may here mention, that a series of seven earthquake shocks, accompanied by *destructive waves* has been reported to have occurred at Lifû (or Lafû), one of the Loyalty Islands, on 28th of March last. Whether any effect of elevation has been noticed I do not know; but Lifû has no doubt often suffered elevation, as I endeavoured to prove in the paper "On the Geology of the Island of Lafû," contributed to the "Proceedings of the Geological Society of London," in the year 1846. In that paper I suggested that there have been several elevations not connected with *visible* volcanic force, but probably due to some elevation of New Caledonia. The recent earthquakes, however, may be considered as a local cause of disturbance, and they are far from infrequent. Admiral Erskine, when in command of H. M. S. "Havannah," experienced a strong shock on 17th September, 1847. The advices from residents in the island last March give reason to suppose that the agitation of the sea was occasioned by a shock outside the island, and that the shakings

within, lasted till 30th March; Tanna, which lies to the N.E., in the direction whence the shocks came, being in eruption. The island of Uvea, to the north-west, appears to have been subject to great disturbances.

This earthquake must have been one of considerable intensity. Letters in the "*Moniteur de la Nouvelle Calédonie*," of 28th April, from Mons. Gaide, missionary at Lifû, dated Gatcha, 4th April, and from Mr. Sleigh, Protestant Minister at Mou, dated 2nd April from that place, give a sad account of the effects of *waves* that rushed to and fro with great violence and irregularity about half an-hour after the first shock, destroying a chapel, villages and property of all kinds, together with twenty-five inhabitants.

The first shock lasted 53 seconds, and occurred at 11 o'clock p.m., the second was felt at half-past 3 next morning, but its duration and violence were less than those of the former.

The times of the subsequent shocks were at 4h.; 8h. 30m., on 29th March; at 3 p.m., and at 8h. 30m. on 30th. The latter was nearly as strong as the first of the series on 28th and lasted about 25 seconds. A great many fishes and thirty-four turtles were cast ashore and captured, but the natives, who lately were cannibals, refused to eat them till the Missionaries gave consent.

Mr. Sleigh says the sea formed several not parallel waves which occupied a range of 8 miles S. to N., and came from a great distance, where doubtless there was a great sub-marine eruption Some of the waves came from further southern points than others.

At Thoth, where seventeen persons in addition to those killed, were wounded, at Mou and at Amele the destruction was greatest, some of it produced by falling buildings, but principally, as Mons. le Rev. Père Gaide says—"*par le diluvio.*"

It will be interesting to determine whether any additional elevation or other phenomenon has occurred in Lifû.

Geology of New Caledonia.

This reference, connecting my general subject with New Caledonia, of which Lifû is a dependency, naturally leads me to a subject, respecting which I am pledged to redeem a promise made

many months ago, when I was unable, from ill health, to bring the matter before you. It will be remembered that a public correspondence, in which more than one member of our Society was engaged, took place as to a claim to discovery of an ore of Nickel, and of Chromate of iron from New Caledonia. I have no intention of imputing any wilful unfairness to the gentlemen who took credit for those discoveries. I suggested at the time that the claim would not have been made had the claimants known the facts of the case; and I repeat here that I have no intention to impute to them anything unjust or unfair towards the real discoverer, MONSIEUR GARNIER. In order to show this I propose to give an account, necessarily very brief, of the Geology of New Caledonia, and, in so doing, I shall draw most of my statements from the writings of my friend, who was appointed in August, 1863, by the Marquis de Chasseloup-Laubat, Minister of the French Navy and Colonies, as Engineer-in-Chief over the mines of New Caledonia. An impression existed at the time that the Island was rich in minerals of many kinds, and that an abundant supply of Coal was also to be anticipated. Monsieur Garnier, finding the latter opinion not likely to be sustainable, determined to devote himself to the more useful employment of defining the formations of the country or their mineralogical conditions. At that time Captain Jouan, of the French Navy, was employed on a Memoir relating to the geological structure of the Loyalty Islands, published in the "*Actes de la Société des Sciences Naturelles, de Cherbourg*," a short notice of which is given in the "*Revue de Géologie*" *of Delesse and Laugel* (III. p. 369 701).

In the "*Revue Algérienne et Coloniale*" an interesting article was also completed in April, 1860, on New Caledonia, by Father Montrouzier, of Napoléonville (a gentleman well known in this Colony), and in 1863, Monsieur Eugène Deslongchamps read a long and instructive essay, headed "Documents sur la Géologie de la Nouvelle Calédonie," before the Linnæan Society of Normandy, which was published in the Bulletin of that Society in 1864 (*tome* 8, p. 332–378), with a description of the fossils

brought to France from the Isle of Hugon, by Monsieur Emille Desplanches and his friend Monsieur Vieillard.

In this paper is a description of the rocks from the Isle of Pines, and of the fossils from Hugon Island, the latter of which is of Triassic formation.

In 1866 Monsieur Garnier had returned to France, and had but a short time to exhibit his collections at the "Exposition Universelle." He was assisted, however, in the examination of his fossils by MM. Brongniart, Vicomte d'Archiac, Fischer, Munier-Chalmas, and by Monsieur Jannettaz, Mineralogist of the Museum.

These are named by me to show that with such skilful aids as some of the best mineralogists, botanists, palæontologists, and geologists of the day to help, the determinations of Monsieur Garnier may be fully relied on, and that it is most unlikely that any mistakes of importance would occur respecting such common ores as Chromate of iron, Hæmatite, or Nickel. It will be seen shortly that though it has been stated that the Chromate of iron was "previously unknown till reported on in Sydney, 1874," and that "the chrome ore discovered by M. Garnier proved to be magnetic oxide of iron," these are mere fictions of some new arrival in New Caledonia, who was as *green* as nickel itself.

On 15th September, 1864, a report to the Governor from M. Garnier, Mining Engineer, dated Port de France, 26th August, was published in the *Moniteur de la Nouvelle Calédonie*, giving an account of his tour through the north-east part of that Colony.

On 5th February, 1865, in the same journal, appeared a Report dated 19th January, from Karigou, on the Coal of that locality, by Mons. Garnier; and afterwards a Report on the district between Port de France and Kanala, including Mont d'Or; the eruptive rocks in relation to metallic minerals in general, and auriferous minerals specially. This Report bears date 3rd May, 1865. On 6th April, 1866, he dates from Port de France, an account of an Excursion in the south-west of New Caledonia

(made in March, 1866). In the "Bulletin de la Sociéte Géologique de France" (2 ser. tome 24, No. 4, p. 438–451), we find a "Notice of the Geology of New Caledonia," by M. Garnier, followed by a "Notice on the Rocks of the Colony," by Mons. Ed. Jannettaz (p. 451–3); and further on (p. 457), is a "Notice of the Fossiliferous Rocks of the Caledonian Archipelago," by Mons. P. Fischer, read on 18th March, 1867, to the Society by M. d'Archiac, in relation to Garnier's paper.

Lastly, in the 12th volume (6th ser.) of the *Annales des Mines*, there is a more extensive, general, and detailed account of the geology, headed "*Essai sur la Géologie et les Ressources Minérales de la Nouvelle Calédonie, par Mons. Garnier, Ingénieur Civil,*" extending through ninety-two pages, and dated "*Paris*, 12 *Mars*, 1867."

Some time in 1858 or 1859, a visit was paid to me by an official gentleman from New Caledonia, bringing a collection of rocks and minerals, which were examined in the presence of M. Joubert, when we saw so much resemblance between them and those of the neighbourhood of Bingera, in New South Wales, as to lead me to report an opinion confirmatory of it, which I afterwards printed in a note to my paper read before the Philosophical Society on 20th Nevember, 1861, and which was afterwards quoted by M. Garnier in three of his publications.

Subsequently, in March, 1863, I received by the hands of Lieut. Bonnefin, of H.I.M.S. "Calédonienne," a collection of specimens from M. Garnier, in which were, with the rocks of the north, minerals, including Chromate of iron and the Nickel mineral, with coal from Mont d'Or; and in a series of letters, commencing in 1864, I was favoured with that gentleman's private account of his discovery of these things. In one of these letters he notices my detection of gold in one of his specimens.

Admiral Erskine, then in command of H.M.S. "Havannah," had contributed to my collections, the former by specimens of Silurian limestone from Hienguéne; the locality, "*Gates of Yengen*," being illustrated by sketches made for me by Mr.

Knapp, the Naval Instructor; and Lieut. Deane, R.N., of H.M.S. "Iris," had also aided my inquiries by bringing over for me many interesting geological specimens, including the Nickeliferous mineral (1858); and Mr. Plews also contributed many useful data, together with a sketch of the scenery and notice of the formation of the great Serpentine range at the back of the harbour of what is now called Nouméa; so that for nearly thirty years I have been kept *au fait* respecting explorations in New Caledonia.

Other persons also, long before 1872, had communicated with me on the Geology and Mineralogy of that country, and since then the question of the Nickel-bearing mineral became of so much importance that I sent specimens of it to England and America, and my friend Professor Dana readily accepted my designation of it as "Garnierite," considering it "a very appropriate one, and otherwise satisfactory"; and it is to be introduced under that name in the next Appendix to his "Mineralogy." This will be appropriate enough also, as in the edition of 1868, under the head of Chromite, we read that it was then known to exist "in New Caledonia, affording ore for commerce." Our Associate—Professor Liversidge—has also been good enough te concede this privilege of nomination to me—as expressed in his valuable paper read last Session—for which I now openly tender my thanks, assuring him that my wish was only so far to interfere as to see justice done to one whose labours in New Caledonia (before Port de France had been re-named Nouméa) deserved such recognition.

The documental evidence for the whole of the above statements is now upon the table.

The formations recognized in New Caledonia by their fossils are these:—

Quaternary—Characterized by species still living on the coast.

Lower Neocomian—Characterized by *Pinna.*

Upper Lias—Characterized by *Nucula hammeri.*

Lower Lias—Characterized by *Ostrea sublamellosa*—*Pellatia Garnieri.*

Trias; Upper—Characterized by *Halobia Lomelli*; Lower—characterized by *Avicula richmondiana.*

Upper Devonian and Upper Silurian—Characterized by *Orthis.*

Azoic—Characterized by *Micaschist.*

Granite is very rare, but it occurs in waterworn pebbles, with quartz rolled, crystallised, pyritous, and rich in Molybdenite, with a little Gold, in the river St. Louis. Schistose Protogine occurs there also in the same way.

Crystallised schists, mostly micaschists, appear on the east coast, a little north of Hienguène, forming a mountain chain close to the sea, disappearing at the mouth of the Diahot and re-appearing in the mountainous islets of Pam and Bulabio. Its course is rather more than 6 miles, and its highest point not quite 4,000 feet (English) above the sea, at Mount Douit, between Panié and Poëbo. The next summit at Poëbo is about 2,800 feet, thence falling rapidly towards Balade, where the height is a little above 1,000 feet, and in the two islets about from 600 to 700 feet. The latter appears to be the height of the patches of micaschists in the south of the island. In certain places these schists are cut by veins of *euphotide;* the quartz veins and reefs contain Pyrites, Epidote, fibrous Tourmaline, and Rutile, and are also the gangue of small quantities of alluvial gold. The strike of the schists is N.N.W. Great reefs accompany the minerals and immense veins highly crystalline, essentially composed of green massive hornblende, garnet, and chromo-green mica, interpolate the laminæ. At Balade the rocks become steaschists. Immediately above these michaschists on the east coast come in bluish fusible slates. Associated with these we find serpentinous and argillaceous schists, which compose the remainder of a great proportion of the rocky skeleton of New Caledonia. They form great reefs in association with magnesian eruptions in composition and aspect resembling Serpentine. Over these, white magnesian schists occur which appear to have resisted the influence of the serpentines to a great degree or to have been less troubled by them.

Associated with the preceding formation there occurs a very siliceous schistose limestone, in twisted and contorted very thick beds which have been much denuded, so that they form isolated, elevated, cavernous, and fantastic masses, sometimes of striking character. These beds extend for fifteen miles between Hienguène and Touo.

There is also an old limestone interbedded with the fusible slates which are met with in the centre of the island behind Houagape, along the river Ti-Houaka towards Poimbey.

Owing to the absence of fossils, all that can be said for these rocks is that they are ancient, and are considered by Mons. Garnier to be either Silurian or Cambrian. It is in the Mica-schists of the oldest of the above formations, that gold was found about Poëbo, in 1863, but in 1864, when Garnier passed that way he found only one digger steadily at work, who afterwards abandoned it. Since then, further trials have been made by English adventurers and others, and if the statements of reporters are conclusive the eventual amount will not be very considerable. As this opinion was given in 1867, perhaps it was too decisive, and hereafter, when the reefs shall have been crushed a larger product may be realized.

The description of the Gold-field may be worth giving. It was situated about two miles frem Poëbo. The bed rock is a garnetiferous micaschist, which is covered by a red clay resulting from the decomposition of ferriferous garnets; the rock sometimes takes a spheroidal form, and in the centre of the spheres the garnet is less abundant and is replaced by a quartzose and pyritous matter, the masses themselves being extremely hard and surrounded by the soft argillaceous products of decomposition. They are often covered with a bed of mammillated oxide of Manganese. That the gold comes from the rock *in situ* was shown by the greater abundance of it in the sands nearest the rock in the dry bed of a river which traversed the deposit of clay.

A supposed Devonian formation occurs next in succession to the older rocks just mentioned, and is exhibited not far from

Nouméa. The beds included in this group are in close connection with a so-called greywacke, holding abundance of rolled *Brachiopods.* Similar rolled *Brachiopods* are known in New South Wales. Fischer believes these beds with *Spirifer*, *Leptæna*, *Megantheris*, and *Orthis*, to belong to the Devonian, whilst Munier-Chalmas considers the rolled shells to have the form of *Orthisina anomala* of the Middle or Upper Silurian of Russia, and therefore would place them in that formation. Limestones and breccias, sometimes of great proportions, almost exclusively compose it; and Garnier mentions that near the Bay of St. Vincent the conglomerate contains portions of the limestone. The strike of these rocks is parallel to the great eruptive magnesian chain, which is N.N.W. The limestones are confined to the islands, Charron, Nié, Brun, Ngou, the peninsula of Nouméa, and part of that of Païta. Felspathic schists form the western coast-line, and after them the breccias occur further north and extend to Kanala. The surfaces of these rocks are extremely waterworn, and have been greatly denuded.

Above these formations come in the Triassic rocks, which have been much disturbed, elevated, and altered by Porphyry associated with the Devonian and with the schists before-mentioned. This Porphyry extends from Mont d'Or to the north of the island and may be traced with the effects of its intrusion in the centre of it. The transmutation that has resulted is in places very striking. The Porphyry is compact and of a dirty white tint, which becomes bluish from exposure; the schists are frequently charged with pyrites and form in nodular masses which have the aspect of Porphyry at the nucleus, and pass into that rock at the planes of junction, when, occasionally, they become, by the presence of angular portions, fine breccia. Now, this is precisely what occurs in New South Wales, on the Peel River, and other places where the igneous intrusions have affected the shells and limestones of the lower Carboniferous formation. The Triassic beds contain several undoubted fossils, viz., *Monotis Richmondiana*, *Turbo Jouanni*, *Spirigera Caledonica*, *Spirifer sp.*, *Astarte sp.*, *Halobia Lommeli*, and a shell, probably a *Myoconcha*,

resembling the *Mytilus problematicus* of New Zealand. These beds are prominent in Hugon and Ducos islands, where they have been much elevated by the Porphyries, or charged with native copper, red oxidulated iron, &c.

To some of the Porphyry Mons. Garnier has given the name of brecciated "*Melaphyre*," which, at best, is a doubtful title, according to Von Cotta, and perhaps only justified by the absence of quartz from its ingredients. In Hugon Island gypsum is not uncommon. In Ducos Island the porphyry contains great crystals of oligoclase, which ultimately decompose to an amygdaloidal wacké, with zeolites and ferruginous globules, taking a spherical form; and through the mass are veins of quartz and rhombohedral calc spar.

It is in the midst of the decomposed porphyry and brecciated "*Melaphyre*" that copper is met with, either diffused in the border rock, or forming veins in the wacké. The latter, however, are separated from from the former by solid porphyry.

Mons. Rivot, *Inspecteur-Géneral des Mines*, who visited Lake Superior, recognizes in the mode of occurrence of the copper the most striking resemblance to that of the celebrated American cupriferous region.

The Coal formation of Nouméa, Mont d'Or, and St. Vincent comes next in order, forming low hills of small breadth, extending from the coast to the central magnesian eruptive ranges. It consists of sandstones, conglomerates, and porphyries. The resemblance of the series to the older Carboniferous strata of Europe is such that a mineralogist might consider them, according to Mons. Jannettaz, of the same age; but the fossils do not justify such a conclusion.

Mons. Fischer, speaking of the beds that occur at Koé over the breccia and conglomerates, says:—"These black schists contain casts of *Littorina* of the group *Capitaneus* (Munster), and prints of *Cardium* and of a little bivalve, reminding one by its size and furrows of the *Astarte Voltzii* of Goldfuss. The absence of *Cephalopods* and *Brachiopods*, as well as the presence of

the above, would lead to the opinion that the shales belong to the lower Jurassic formation." But, says Garnier, Mons. Deslongchamps having found in the Triassic beds of Hugon casts of *Astarte* and *Turbo* near to those above named, Mons. Fischer thought the formation might be Triassic also.

Munier-Chalmas recognized four *Lower liassic* shells, an *Ostrea* probably *sublamellosa*, of Dunker; a *Pellatia*, a genus common in Burgundy, and named *Garnieri* after Mons. Garnier; *Cardium Caledonicum*, and a *Turbo*.

The shales are surmounted by the beds containing the coal, and in the midst of them occur two species of *Nucula*—one of which (*Nucula Hammeri*, de France) belongs to the Upper Lias. Mons. Garnier says: Professor M'Coy has determined coal beds in New South Wales belonging to Triassic and Jurassic strata, with *Belemnites giganteus*. But this is a mistake; that fossil or its representative belongs only to Queensland.

At Koé the coal is anthracitic, sometimes graphitic, intercalated with the shales and resting on a serpentinous sandstone ("*grès metaxite*") a vein of which passes through the Anthracite. Small undetermined Bivalves and fragments of plants occur in the shales at the contact with the coal. Monsieur Bongniart recognizes a similar occurrence in the Devonian anthracites of Mayenne. The shales are pyritous, argillaceous, and fusible. Vicomte d'Archiac classes them with the *Upper Lias*.

At Karigou the coal has been rendered anthracitic by a vein of Euritic porphyry which has elevated the beds, and prismatized the coal, changing it to a condition of graphite, with calc spar, and numerous crystals of quartz. In the midst of the shale or anthracite there is abundance of phosphate of iron, covering the rocks and coal with a bluish coating.

To the north-west of Mont d'Or the coal is bituminous and highly inflammable, and occurs in nests rather than in beds of friable sandstone, rapidly decomposing and only subsisting when in contact with hardening igneous rocks. This coal is very impure and of very little value; and from its position, flanked by

the ocean on one side and an eruptive mountain on the other, offers little expectation except to persons easily satisfied. The Mont d'Or deposits are accompanied by Euritic porphyries. At Koé, Mons. Garnier noticed the same kind of sparkling semi-crystals of quartz after rain, while I have noticed in our own sandstones to which he refers, quoting what I have stated of it in mention of what he calls "The great Hawkesbury." From Mont d'Or to the plain of St. Louis, the hills of Carboniferous sandstone alternate with Euritine, which is described as a sedimentary rock accompanying the coal, and difficult to distinguish from true "eurite." In passing from Koé to Paita, the porphyries were found coloured by a green matter not determined at the time, but appearing to contain Nickel. (See *Annales des Mines, tome* xii. p. 55.)

The extension of the coal formation along the south coast is shown on the map which I have coloured after Mons. Garnier, and placed on the table, for the purpose of illustrating the subject.

The Micaschists in the North which we first noticed, form the eastern boundary of a plain, in which the river Diahot, the largest in the island, rises from the auriferous locality already mentioned. On the left bank of this river coal is again found. It is also the habitat of copper, which is now giving promise of some consideration.

Near Nouméa (*au Bois Leclerc*) calcareous sandstones occur oftentimes in spheroidal masses, and in the centre of the spheres a fossil appears, which Mons. Munier considers to be identical with an undescribed new species of Pinna, belonging to the Upper Neocomian of France (Green-sand of England). This sandstone abuts on the felspathic sandstones.

Between Nouméa and Pont-des-Français, a bluish argillaceous limestone, contemporary with the porphyries, contains geodes of carbonate of lime and nests of black waxy clay, strongly impregnated with bitumen, probably the result of distillation from coal since the inroad of the porphyries, which have altered the limestone and induced a concretionary spherical structure.

Over all the beds and on the heights of the Nouméa Peninsula and the neighbouring islets, and on all the hills about Païta near the sea, is found a very recent limestone with some badly preserved remains of living shell-fish.

White, and sometimes a little grey, and so earthy that it is easily penetrated, it contains from 9 to 12 per cent. of clay, which is a good proportion for hydraulic purposes. It is easier to work, and is freer from water and salt than coral. This limestone is very similar to that which composes the Loyalty Isles (Maré and Ouvéa), and it is met with in the Isle of Pines, &c. At Lifû the limestone contains casts of shells, which Mons. Fischer has recognised as those of *Terebra, Turbo, Trochus, Psammobia, Cypricardia, Nautilus, &c.*

In the Houagap valley also we meet with a very recent micaceous fine-grained argillaceous sandstone.

We come now to the most important formation of New Caledonia. The eruptive Magnesian rocks form, in fact, the greatest part of the prominent profile of the country—or we might rather say that the formations already mentioned are only isolated patches in the midst of the Magnesian eruptions.

If we imagine a broken line shooting from Mont d'Or to Ouitchambo and Ouailou peaks, the mean direction of which is north-north-west, all the part of New Caledonia placed to the south-east of that line is nearly exclusively formed of magnesian eruptions, essentially represented by serpentines, with or without diallage—*Euphotides*, *Amphibolites*, and *Diorites*. But this is not the whole extent of these rocks; they show themselves also on the west coast, particularly at Ouarai, Kone, Gatop, Paquiêpe, Cape Duverd, Koumac, Néoué, Tanlep, Néba, Nandé, and Belep. The great surface occupied by these eruptions compared with the sedimentary formations, would induce us to say that the Island is nothing but an elevation of magnesian rocks in the midst of which there remains here and there a small overthrown islet belonging to the old sedimentary formations. These magnesian rocks have contributed the most important forms which the island now possesses; but their composition is such as

to have favoured extremely the operations of denudation, by the action of which the deep ravines and gullies have been scooped out. The action of currents and waves has also produced great changes in bays and channels between the islets along the coast; and tradition relates that the Woodin Canal, which separates New Caledonia from Ouen Island, was thus comparatively recently formed. The inhabitants of that island state that the *Kagou*, a bird which can neither swim nor fly, came formerly from the mainland to the island, where it no more exists, and (as it appears) could not now exist. The Kagou (*Rhynochetos jubatus* of naturalists) is one of the wingless birds so common in the Pacific islands. Its constitution is somewhat akin to that of the ostrich.

The Isle of Pines, situated exactly on the prolongation of the axis of New Caledonia, is the same in geological structure, and Monsieur Garnier regards its isolation to be due to the removal of the argillaceous and soft magnesian deposits. He also explains in the same manner the separate masses of reef between the two Islands, showing how the width of the bases of the separate masses is gradually being undermined, and therefore, in process of time, the coral will remain as the sole indication of former dry land. This explanation is applicable to the north and south alike, and satisfies the inquiry as to the manner in which several small islands of magnesian rocks occur in the broken line of the reefs. This consideration does not, however, interfere with conclusions derived from the action of subsidence which, united with denudation, has probably changed the character of many tracts of land in the Pacific. It may, however, be remarked, that subsequent elevation would produce narrow ridges with steep sides, as is the case in Lifû, where the coral has been raised in three steps or ledges. This I have shown in the paper on Lifû before-mentioned.

Serpentine seems to be the oldest rock of this series, affecting various aspects of colour and texture. "Often," says Monsieur Garnier, "it contains crystals of bronzite diallage, and almost always chromate of iron." At Koè and Mont d'Or it is of a deep

green, and takes a good polish. In this condition it is often traversed by veins of chrysolite. At Kanala the structure is fibrous. In the north-west, at Koumac, it is sometimes yellowish-grey, containing much chromate of iron. Elsewhere it takes the schistose structure, and recalls to mind the white argillaceous schists which are intimately associated with the serpentinous schists.

A remarkable common character of the Serpentines is their containing immense masses of red clay, derived from the decomposition of the rock itself, when it contains Diallage in abundance. In this case, in the midst of the argillaceous masses, there are heaps of chromate of iron, also limonite, with diallage in nests in different stages of decomposition. But the Serpentine does not always end in clay; sometimes both in the north and in the south it loses its magnesia, presenting only a fibrous skeleton of silica, which in certain instances passes into a green or white Opal with dendrites; the opal also becomes mammillated. The fibrous skeleton passes sometimes into pulverulent silica with, occasionally, carbonate of magnesia.

Very pure veins of hydro-silicate of magnesia, with a mammillated structure, appearing as if precipitated, occur in the midst of the Serpentines in the south of the island. Monsieur Terreil analyzed this hydro-silicate at the Paris Museum, and found its indications very near those of the Gymnite of Massachusetts.

This rock, which is commonly yellowish blue, a little translucent, is elsewhere, *e. g.*, at Kanala, strongly coloured green. The colouring matter, after numerous and patient investigations by Monsieur Jannettaz, appears due to a Silicate of nickel, which, as we shall presently see, says Monsieur Garnier, is very frequently represented in the midst of the eruptive magnesian rocks.

"In fact, the serpentines themselves are frequently covered with a green coating, which is no other than this silicate of nickel; the cavernous quartz which particularly at Koé, abounds in the serpentinous formations, has the cells more or less commonly filled with the silicate of nickel.

"In the neighbourhood of Mont d'Or, and at Koé, may be noticed in the midst of immense masses of clay, which accompany the serpentines, numerous veins of Hyaline quartz; sometimes, as in the locality Latouche-Téré, at Koé, this quartz has in the midst of the clay enormous proportions, and is sometimes covered with green coatings, which again appear to be the silicate of nickel."

The last two passages are translated literally from the text of Monsieur Garnier, in order to present his own statement so as not to be mistaken.

Of the *Euphotides*, *Diorites*, and *Amphibolites*, I have no time to speak at length. I may mention, however, that the former are often charged with red iron oxide, seemingly derived from the decomposition of the diallage, in which case there occur masses of clay and impure kaolins, in the midst of which are kidneys of pyrolusite and nests of oxidulated magnetic iron.

In the south of Ouen Island these *Euphotides* pass into a jade, which is sometimes green, changing to a white. In decomposition sometimes portions pass to serpentinous schists, whilst the more compact pass to felspar, accompanied there by little Ouvarovite (*i. e.* lime-chrome) garnets.

Diorites are frequent in the midst of the magnesian eruptions, and often pass into Amphibolite, which always occurs in veins in the midst of the serpentines.

At Koé the diorite is composed of great crystals of hornblende in the midst of the felspar of decomposition, and is coloured green, probably also by the silicate of nickel.

In the account I have now given of New Caledonia I have followed carefully M. Garnier's statements, and have sometimes introduced a strictly honest translation of his remarks, especially in what he has said of the Chromate of iron and silicate of Nickel, quoting sometimes partly from his paper in the "Bulletin of the Geological Society of France," and partly from his larger essay in the *Annales des Mines*. A few references to his other remarks may be equally satisfactory. Writing of the iron ore,

which it has been asserted he mistook for chromate, he says:—"All the banks of the South Bay and the Woodin Canal on the side of the main land are composed of the same schistose serpentines among which Hydroxide of iron is abundant." Again: "The river in question (Nécoutcho) flows in the midst of clays and serpentine rocks; its banks are very abrupt, and the hydroxide of iron is abundant. I ascended the Hono-Kouao, the chief branch of the river, through its whole length, and met rocks of serpentine and immense blocks of hydroxide of iron upon its banks. It is there that the Kawrie" (*Dammara ovata* of our associate Mr. Moore) "attains dimensions truly remarkable." "If" he goes on, "we traverse New Caledonia, from the east coast, we find even to the north of Goro this formation of serpentine and iron ores. Beyond, these minerals are more rare; but when we see these mountains entirely composed of hydroxide of iron, rising from the sea shore from the depth of safe harbours, we ask why ships of commerce, which always leave New Caledonia in ballast, do not come home loaded with this mineral, which may have a sufficiently high value. At Sydney, for example, the furnaces of Fitzroy would perhaps take a good part of this ore, which they could have at a low rate.

"This ore of iron is an anhydrous silicified peroxide more or less mixed with limonite; the dry assay has given a proportion of 51·30 per cent. of iron. Moreover, this ore always contains disseminated through the mass a certain quantity of chromate of iron. Now, steel containing in the state of '*alliage*' 2 per cent. of Chrome, according to Berthier, loses none of its malleability and attains even an extreme hardness."

Further, of the bay N'go he says—"Ships may anchor in perfect security; a beautiful river flows into it, the surrounding mountains are high and covered with ferruginous red clays, containing masses of hydroxide of iron. Such is the Kouré Peak, symmetrical with Ja Peak (height about 1,600 feet), placed as this is on the border of the sea, and in the south-east of the bay N'go."

I wish I had time to repeat his description of Mont d'Or, a vast igneous mass with precipitous sides, on the summit of which,

he says, the ore of iron, with Chrome, presents masses more or less voluminous, but commonly of the size of one's head. In some places there are heaps of these lumps, some cubic mètres in volume. These are explained by the natives as piled up to be used as veritable shot in a contest with the natives of the Isles of Pines and Ouen, who came to ravage the plains of Marari and Boulari. On the east side of the south-eastern extremity of Mont d'Or there is a mass of crystalline chrome ore, and descending towards Khouen a series of chrome ores is met with. This mineral is found in nodules in the Steaschists of Balade, to the north-east; in crystalline grains in the serpentine schists of the south and of the north-west; in crystals more or less voluminous in the diallagic serpentines—the diallages, the ores of iron of the south; in amorphous masses, also, and in heaps more or less considerable in the clays in the midst of the serpentines. Lastly, chromate of iron composes almost exclusively the metalliferous black sands which cover the banks throughout the south of the Island and the beds of the rivulets which circulate in the serpentines. Among all the modes of deposit of the chromate of iron, there is only one which presents this ore in such abundance and purity for remunerative working as that where it shows itself in heaps amidst the serpentines, and which we find in Mont d'Or. Everywhere in traverses of the mountain he met these heaps more or less.

He calculates that the cost per ton of this ore from the quarry to France will be something under 12 francs, or 10s. He then gives the mean of two analysès of the chromate of iron, of which one was made at the School of Mines of Saint-Etienne :—

Peroxide of iron	34·000
Sesquioxide of chrome	61·333
Alumina	0·114
Magnesia	0·012
Silica	4·625
Loss, &c.	0·016
	100·100

The proportion of 61·333 per 100 he shows to be the greatest in the works which give the analyses of chromates of iron from l'Aveyron, Styria, the Ural, Silesia, St. Domingo, and Baltimore.

Of the nickel ore he says the cavities of the rock on the river Dumbéa are filled with magnesian silicates, impregnated with a green nickeliferous substance which colours them, and which up to his time was taken for a certain condition of chrome which is common in the quartz itself; Mons. Jannettaz stated the true nature of this colouring.

The Nickel, he remarks, is met with under the same conditions accompanying blackish serpentines with nodules of green matter; at Kanala nickel shows itself again colouring strongly a magnesian silicate. I believe it is now being wrought at that place.

Then he concludes:—"It will be highly interesting to study more completely the deposits of nickel in New Caledonia, and to see if industry could not draw from it a part of the metal, the price of which, as we know, is so high, and the employment of which in certain cases offers so many advantages. At first, in consequence of the intimate mixture of the nickel with the magnesian silicates, one might say that the treatment of the metal on the large scale would more easily succeed by the moist way."

At the close of his Memoir in the *Annales des Mines*, he says: We have seen in the north metalliferous sands; in the south, in the midst of rivulets and their banks in contact with serpentinous rocks, there is also a great abundance of metalliferous sands essentially composed of chromate of iron, ordinarily in little crystals—oxidulated iron, &c. I will state, in addition to my friend's remark, that it has been ascertained that Serpentine generally contains just such crystals, wherever it has been analyzed.

As a fitting appendage to the preceding abstract, I consider it right to read the last document of Monsieur Garnier, which I have translated from the French Official journal, the *Moniteur de la Nouvelle Calédonie*, of 6th January, 1875, where it appears

under the title of "Minerals in New Caledonia," prefaced by the editor of the *Moniteur* in this way: "M. Jules Garnier, whose name was found mixed up in a controversy between various correspondents of the *Sydney Morning Herald,* translated and published in the *Moniteur* of the 24th June last, has addressed to us the following explanations, praying us to insert it."

"Since I left New Caledonia several years ago I have not ceased to keep myself up to the course of its progress. I was of the small number of those who, from the beginning attributed a veritable fertility to a good part of the soil of the Colony and mineral wealth to the other part. I have also seen with pleasure my convictions being realized more and more under the energy and indefatigable application of those courageous colonists, with the first of whom I have had the pleasure of being acquainted.

"Too distant to reply at once in the case where my ulterior studies of the country might allow me fully to do so, I would certainly never have attempted it if my name had not been introduced into a discussion as to the priority of the discovery of minerals.

"And first, let it not be forgotten that the true end of men of my profession, *i.e.*, of geologists, is not in particular the discovery of mines, but rather to state in what points, within certain limits, there is a chance of finding such or such a mineral. A geologist is an isolated being, if not a rare one; the mine-hunter may be called legion. The first has but one track, the second has a thousand; the former does not neglect the most humble rock, the latter only stops at scintillations, at metallic lustres, at aspects of useful minerals of a special kind; lastly, the geologist—may my brethren forgive me the comparison—is the indefatigable pointer that shows the mine-hunter where his game is going.

"Notwithstanding, it would appear that my writings on the constitution of the soil of New Caledonia are not even read by miners; so much the worse, for they might have discovered certain indications of what has been since found by them in the colony. It appears that there, as here, too often people do not

read, forgetting that grand truth that 'everything is in the books for him who knows how to look for it.'

"As to the 'chromate of iron,' that faithful companion of the numerous rocks of the colony, our esteemed colleague, W. B. Clarke, did not miss noticing it in 1861.

"On my part, in all my Reports or geological writings, I establish the presence of the mineral in so many places in the Island that it would take too long to enumerate them here. But it was on 20th February, 1866, that I met with the first habitat of workable chromate of iron, as I have just read in my journal: "28th February, to re-ascend Mont d'Or, setting out from the marshy plain of *Khouen*, where I passed the night to seek if there were any new sites of chromate of iron. I have found some heaps of it, purer than that which I met with at the first time—18th November last—in the Cascade River." I attributed then a certain importance to this discovery, for on 19th March, 1866, I addressed to the Governor a detailed report on the question. It was published about that date in the *Moniteur*, and to it I refer my readers.

"At that period the mineral in question was worth nearly 200 francs a ton; now it is another thing. Turkey and Greece have developed the opening of sites of this mineral, and it can be procured at from 60 to 70 francs per ton. As elsewhere, the employment of this matter is limited to some thousand tons per annum; we see, consequently, the decrease which this new condition brings to the deposits of this Colony.

"One of the letters which encouraged me to write this, pointedly notices as astonishing the error which was committed at Mont d'Or, where people have taken and exported 'oxidulated iron' for 'chromate of iron.' Nothing, on the contrary, is less surprising; for every mineralogist knows that the two substances are so like that the most experienced person has almost always need to distinguish them by an examination in the closet. So far as I am concerned I have never omitted to point out this fact beforehand to persons who asked me the *indication*

of 'chromate of iron,' recommending them strongly, in order to avoid all confusion between the sites which are close together on Mont d'Or, always to try the mineral before taking it away. However it happens, is it not singular that they rest on this error committed by persons evidently but little initiated in the knowledge of minerals not only for invalidating my discovery, but besides for claiming it themselves?

"If we pass on to the Nickel, it will be, I think, as easy to demonstrate that the priority in finding it belongs to me. I have recorded this in my journal:—'24th September, 1864, continuing to ascend the river of Dumbéa . . . . the rocks which I meet with are little variable, they are Amphibolitic and often hold chromate of iron. The rock is also accompanied by a green matter which sticks to the surface—Nickel. Moreover it was one of the first steps in the country to announce nickel. I sent specimens of it to the Rev W. B. Clarke, as he has had the goodness to state in his letter. I did not then give the descriptions, waiting for the definite work which I could only make in a place where I could be aided by the light of clever experiments, and also with instruments for investigation which I lacked in the Colony. It was Mons. Jannettaz, Mineralogist at the Museum, who was so good as to analyze this green substance, which was thought might also be chrome in a certain condition—the oxidizing salt—if we might judge from the abundance of chromate of iron in all the rocks—the analysis of Mons. Jannettaz gave me satisfaction. It was really that of Nickel; and I was then able to say in my 'Geology of New Caledonia,' p. 85 (1867):—'It would be highly interesting to study more completely the deposits of Nickel,' &c. [Already quoted.]

"In 1869 I again wrote:—'The serpentines, and in a general way of the rest, all the rocks which accompany them are often covered with a coating of beautiful green, which is nothing but silicate of Nickel, alumina, and magnesia. . . . The Nickel in this condition is so abundant that we ought to hope to find one day a workable deposit of it.' [*Bulletin de l'Industrie Minérale, p.* 301, *tome* XV.]

"If we return to the letter which the Rev. W. B. Clarke has been good enough to address to the *Sydney Morning Herald* on this question, it will be seen that he was himself pre-occupied with this mineral belonging to our Colony, which I had previously sent him unnamed; but as he had also received from me, a little after, my Geology of New Caledonia, it is still possible that it was from that moment his curiosity was aroused, and that he caused to be analyzed, as he now informs us, the specimen which he possessed, which he communicated to the celebrated Professor Dana of the United States, intended to be mentioned in his next edition of his Mineralogy.

"In any case, the composition of this mineral, which I indicate above, ranges, as Mr. Clarke has made it, in the very numerous family of Pimelites, Alipite, Chrysoprase earth, &c.*

"But to return to the practical question. Since the time when I noticed Nickel in my writings, the price of this metal has been raised from 12 to 45 francs *per kilo* to actually fall in France to about 35 francs; it was then that I very earnestly persuaded persons at Paris interested in New Caledonia, to work the nickel there; and it was at that time also I had knowledge of trials, in the true sense of the word, which were made in the country. I will add that the high prices of nickel have immediately led to the resolution of taking up again in Europe a quantity of mines of this metal, which were abandoned as too poor, insomuch that a certain reaction was to be feared, especially as the employment of this metal is limited. Apart from its utilization as money in America, in Germany, in Belgium, and in Saxony, nickel is confined to the manufacture of incrustation of wood for arms, ornamental boxes, rich harness, &c.

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* Monsieur Garnier has fallen into an error here. I never received from him his "Geology of New Caledonia"—and it was only in 1874 I sent the specimens to Professor Dana which I received from Mr. Tully, of Newcastle, in 1873 [M. Garnier's specimens are still in my possession]; and the analyses I published were those of Dr. Leibius and of Professor Liversidge, to whom we are indebted for a valuable paper read to the Royal Society in 1874.

"It is also to be feared that the market suffers by the great consignments made by America, where, for some time, in Pennsylvania, a considerable lode of copper and nickel has been wrought. In Sardinia also have been recently discovered rich veins in which nickel is associated with cobalt and bismuth; and I have it from a good authority that they cannot push on too actively the work for fear of a lowering of the price. Up to this time nickel has been derived from mineral veins; but the New Caledonian variety is rather to be found in bunches, and like all those kinds of deposits has the fault of being discontinuous and irregular. But the ore will only require a simple metallurgical treatment, on account of the elements which compose it being easily eliminated. Without doubt the mineral ought to be mechanically enriched up to 15 or 20 per cent., in order to utilize as much as possible the deposits, and to have a clear product supporting the cost of carriage; besides, the price of the ore of nickel, and by the kilogramme of contained metal, rises in proportion to the richness of the ore. At 20 per cent. the ore is worth about 2,000 francs per ton in Europe.

"Before the close of this letter, I would say another word on the gold and the coal.

"My conviction has never varied as to the presence of vein gold; it shows itself in all my writings, and I have reason to think that 100 kilomètres of the old formations on the N.E. coast are the receptacle of numerous veins of precious metal and of its companion, copper.

"As to the coal, the question is more delicate; however, when I reflect with the experience I have acquired since I left the island, and when I revise with all the distinctness of recollection the long Carboniferous zone which composes almost everywhere the west of the colony, starting from the south at Mont d'Or, I cannot prevent myself from believing that we are there on the shores of an important Coal-sea—shores moved by gigantic displacements produced by the arrival of the different eruptive rocks upon which now repose the Carboniferous formations; but

far away to the west, the coal ought to exist with all the regularity which composes its formation. Unfortunately, on the west side is the sea; and the actual level ought to be raised some hundreds of mètres to enable us to easily work out the riches to which the Ocean now interdicts the access. In fact, it is probable that the waters which actually cover the ancient coal-beds have preserved them from the destruction which those have suffered that were emerged, *i.e.*, exposed to the violence of atmospheric erosions. That which is here remarkable is, that frequently the rocks that accompany the coal are very friable and decompose into sand under the feeblest force.

" Whatever the cause, as I have said in my 'Geology' p. 53, 54, the plain of St. Vincent may cover coal deposits, whilst on the upper part of the Ouenghi River, where I have found traces of coal, where the eruptive rocks are less abundant, where the Carboniferous zone shows itself on a broader area, we ought to have solid expectations of finding a working combustible.

"At Mont d'Or search for coal would be venturesome and costly; it would consist in the sinking of a shaft situated in the spot I have pointed out under the name of '*Ilot au charbon.*' This shaft, if it did not meet with the beds of coal, which in these shore-districts sink beneath the waters, ought to be, at a certain depth, the point of departure of adits suitably directed for traversing the strata. But, I repeat, that would be an enterprise which would require an important expenditure of capital and able engineers. The geographical situation of this locality as well as the pretty good character of the coal I have seen, nevertheless, would justify this trial.

"JULES GARNIER."

" P.S.—I have just looked over, before I send off this notice, my geological collection from New Caledonia, at the Permanent Exhibition of the Navy and Colonies. I have not found there less than eleven specimens of rocks marked on the labels, and in the catalogue as '*nickelifère.* Many specimens are also so rich in nickel that I believed (in 1867) that it was right to arrange

them in their place in the glass case appropriated to utilizable minerals; I could not do more to advise those interested.

J. G."

It was not strange that when the correspondence referred to about the claims to discovery reached France (which it did without my interference or knowledge), Monsieur Garnier should feel it a duty to himself to place the matter before the world in its true light. And in thus bringing it before this Society, I am merely discharging a duty to a colleague in the Geological Society of France, who years ago honored me with his confidence in the discoveries he was making in New Caledonia; as well as offering to my fellow-colonists in New South Wales the results of his experience, hitherto clothed in a language foreign to many among them; whilst, at the same time, I have vindicated my own right to have interposed in an affair which, from my association with Monsieur Garnier in his investigations, I feel myself called upon a year ago to pledge myself to do on the first opportune occasion of addressing the Royal Society. I have now redeemed my pledge, perhaps to the weariness of some here present; but I could not do less, nor am I called upon to do more. But I will repeat the assurance before given, that I have not wished to impute anything wilful in the claim of any one to the discoveries of "Chromate of iron" or "Nickel" made by the gentleman whom I have thus introduced to you to-night; for it is clear the claims arose from ignorance of the facts just explained. But it may be well by this example to show the danger of men doing what is growing very common in this country—the danger of seeking notoriety by mistake and claiming as their own what belongs to others, without first carefully inquiring into the facts of the case.

Had a mistake of this kind been confined to the Colony, it would not have been of so much importance. But, unhappily, nearly all the correspondence in the Sydney papers of 1874 has found its way into a "Prospectus" of a "Mining Company" in London, for the "*working of Nickel, Cobalt, and Chrome*"; and in this Prospectus, all the conflicting claims of various per-

sons, except the right one, are made prominent. It has, therefore, been only an act of conscientious duty to show on whom the wreath of honor should be bestowed.

The controversy, as it has been called, had, however the advantage of making prominent the assays of our Secretary, Professor Liversidge, and leading to the valuable paper which forms No. 7 in the contributions to the Transactions of the last year.

Geological Survey of New South Wales.

It was my wish to offer some remarks on other proceedings of this Society, but I have been so profuse on two subjects as to have left little time for even a mention of what has been unavoidably omitted. Last session I was unable to take part in its proceedings, but the cause of my absence from them led to some useful work in another direction. Moving about in search of change of air and scene, I was enabled to examine a considerable tract of auriferous country before only partially known to me, and I have also materially assisted in extending our knowledge as to the existence of the Middle series of Palæozoic rocks in this Colony, which, on former occasions, I had identified in other parts of the country.

I may mention that the Devonian formation is widely diffused in New South Wales; and I have had eighty-one species determined for me in Europe, besides numerous Upper Silurian fossils. They form part of the collection of 1,000 individuals which I mentioned as having been sent Home by me, in the Anniversary Address of 1873 (p. 17).

The establishment of a Mining Department will, no doubt, diminish the labour of persons like myself, who have neither the staff nor the pecuniary aid which enables such a body to make acceptable surveys and discover new repositories of mineral wealth. The work, however, which has been for years performed single-handed by myself has not, I trust, been without its use, and new comers may dig out of my reports, memoirs, and essays, much that may form a basis for fresh speculations and new details.

I am thankful that I am able to say from personal observation that my young friend, the Geological Surveyor, who earned his spurs under Mr. Selwyn, in Victoria, is deserving of the fullest confidence in his new field, and will before long establish his claim to it. But in this large Colony, the area for accurate geological survey is so extensive, as he well knows already, that it cannot be completed for a very long period, and probably will not be during the present century, and then not without an enormous outlay, which will some day alarm the economists of Parliament. This department ought to have been established thirty years ago, and I have often regretted that no record has been kept of the observations of the thousands of gold-diggers and others who have had as it were a good part of the Colony in their hands so long, and might (some of them at least) have contributed valuable information now lost to the world.

Geological Maps.

In endeavouring to make up for more official inquiry, it has been a satisfaction to me to have done *mon possible*, though at present, according to the Secretary for Mines in Victoria, the Geological map of New South Wales is a blank, or, as he words it, "as regards New South Wales, there was a white sheet," which was nevertheless enabled to be coloured "in a short time." They do things in marvellously quick ways elsewhere. Here observers have been obliged to see for themselves and form their conclusions from observations, so that persons who have never been in our territory may reap and glean for their own garners.

It was refreshing to me, however, to read the following announcement in the *Melbourne Argus* of 17th July, 1873, and which was reprinted in *Nature*:—"The New South Wales Government have in preparation a geological map, which, it is expected, will be available for use before the general map is published." It is the first time we have heard of this admirable intention and work of the Government, and could I believe the statement as of a fact, I would readily retire from labour of a similar kind on which I have been employed for many years, and

of which so long ago as 20th December, 1872, our Parliament was made aware, in a letter of 19th October, 1872, from the Surveyor General, who, in reference to my humble endeavours, did me the kindly honor of thus recording his opinion:—"These labours appear to embrace an examination of all the principal geological features of the Cólony, made at different times throughout the period of his residence, and if the work be as complete as I have every reason to believe it to be, it could not be replaced by a geological survey costing less than £10,000 or £15,000."

Since that time my map has been nearly completed, and would have fully been, except for causes beyond my control. But should this map be that mentioned by the correspondent of the *Argus*, I can only say it has not yet passed out of my hands.

In thus speaking of the past, and of the endeavours of my Southern friends to display the Geology of all Australia and Tasmania on one sheet, I neither wish to detract from their usefulness nor to overrate my own. I am under no egotistical influence, though I am compelled to speak in the first person and of myself; and I do so now, because it is the most fitting occasion for so doing. I have no doubt the Victorian map will be prettily got up and filled with valuable matter. But so far as *this* Colony is concerned, it cannot be authorized on the *personal knowledge of the compiler*, and will be formed from individual interpretations of writings, as well as surveys, which may require revisal. It would have been more agreeable to me to have consented to the request made to me in an influential quarter, and have forwarded a copy of my work to Melbourne; but I could not do this, because if I had I could not expect a gentleman, however long known to me as a correspondent and professed friend, who regards my views as to the relative age of a large part of our territory to be erroneous, and who openly ignores the evidence offered even by Victorian surveyors, who have confirmed those views, to do otherwise than substitute his own conjectures for those he asserts he has not seen "a particle of evidence" to confirm. Common prudence dictated that it would

be suicidal to do so. And it is in every way better that responsibility to the public should be held by those who presume to direct its judgment. This is not said invidiously, but in explanation of the course I have seen fit to take for my own satisfaction. When the Secretary of Mines applied to me by letter, I stated how I was situated, and that he had wished for aid in his undoubtedly well-intended good work, *without stating what aid he required.*

All that New South Wales is credited with is a "white sheet." Yet I do not doubt that she has supplied in various ways, and by various contrivances, by far the greater part of the materials which are to be employed in her service or disservice; and it is more than possible that some portion of what I have myself mapped down may have been carried over the border. Whether the geological world at Home will consider such a plan sufficient is not my business to inquire.

Yet one may feel inclined to doubt whether any of the surveys that are to be embodied in one grand piece of geological patchwork are sufficiently perfect to allow them to be combined at present with actual advantage to science, and by a compiler who has not had the means of such supervision of them as would be necessary if the comparison of such distant and separate regions, with a view to definite boundaries and *actual identity and formations* be the one sole object for publication of surveys and other collected data. Over these, even in the absence of copyright, no compiler can have a legitimate claim to exercise control or to make alteration in them so as to suit a theory or a conjecture that must undoubtedly involve some contradictions which even the audacity of genius cannot correct.

Professor Jukes put forth the first sketch map of this kind in 1850, in his "Physical Structure of Australia," but not without encountering some unpleasant criticism at his boldness. In the new "Sketch of Maps" there will be the same danger of not satisfying more than the curiosity of a portion of the public; but it would be to exhibit a want of loyalty not to wish for the compiler all the advantages to the Colonies at large which his various contributions may unite in securing.

Plants.

One other special topic deserves to be mentioned. Baron von Müller, of Melbourne, whose botanical labours have earned for him the honors of rank and distinction, has recently turned his attention to the vegetable remains entombed in the gold leads of Victoria and New South Wales. In his Report respecting them he stated that he had not received any *leaves* of the plants he had described. It was my good fortune in February last to discover several leaves in the rejectamenta of one of the leads in this Colony. These I forwarded to the Baron, who, after examination, sent them to Professor Schimper, of Strasbourg. We shall, therefore, soon have fuller knowledge of the vegetation of Australia just previous to the time of the present flora.

Tin.

Before I conclude, I might properly refer to the discovery of tin ore in Tasmania. Much has been said respecting it, but little is actually known.

I have, however, just received a Memoir on the subject from Mr. Wintle, an accute observer in that Colony, who has entrusted it to me, with a request that it may be laid before this Society; and I will therefore place it in the hands of the new Council at its first meeting. It will be illustrated by a collection of rocks and metals gathered by the author.

W.B.C.

10/5/75.

NOTES ON DEEP SEA SOUNDINGS.

(SUPPLEMENTARY TO THE ANNIVERSARY ADDRESS OF 12TH MAY.)

By Rev. W. B. Clarke, M.A., F.G.S., V.P.

[*Read before the Royal Society,* 1*st December,* 1875.]

Although I endeavoured, in the first part of the Anniversary Address of the present year, to bring together a number of instructive data respecting the condition of the bottom of the Atlantic and Pacific Oceans, as shown by the observations and researches of the Officers and Scientific Staff of H.M.S. "Challenger," that account was necessarily incomplete. It was merely a detail of work in progress, requiring the addition of fresh material.

In the design of such continuation, I have thought it advisable to lay before this Society some fresh statements and conclusions, collected from various sources, not doubting that they may prove interesting to such as gave willing audience to my preceding remarks.

(I.) By the kindness of my friend Captain F. J. O. Evans, R.N., C.B., F.R.S., Hydrographer to the Admiralty, I have been put in possession of two reports from the "Challenger"—the former dated from Hongkong, by Captain Nares, on 19th November, 1874, to which are appended "Extracts from the Remark Book of Staff-Commander T. H. Tizard on the temperature of the seas partially enclosed by the Indian Archipelago"; the latter entitled "Hydrographic Proceedings," being a communication from Captain Frank T. Thomson, successor to Captain Nares, in command of the "Challenger," bearing date Yokohama, 11th April, 1875, also supplemented by Commander Tizard. These Reports are illustrated by sections of the ocean between New Zealand and Fiji; Raine Island in the Barrier Reef, Appi, and Kandavu, the Banda, Celebes, Sulu, and China Seas, together with the Isothermal lines at different depths.

By these Reports I am enabled to fill in the "gap" between New Zealand and Cape York, mentioned in my "Address," and to add something in relation to the coasts and ocean further north. The last previous Report of Captain Nares bears date 17th March, 1874; the present one, therefore, is to us a new official document.

On 14th and 15th July, 1874, the "Challenger" was in 600 fathoms water, in the neighbourhood of the Kermadec Group, the bottom composed of lava pebbles and pumice, and dangerous to the trawl.

The weather prevented any determination of deep or shallow water between that group and New Zealand. On the 17th July, in latitude 25° 5′ S., and longitude 172° 56′ W., the depth was 2,900 fathoms, and bottom temperature 32°.9, proving a deep continuous channel from the southward to those seas. She was at Tonga-tabu on 19th and 22nd July, reaching Kandavu on the 25th, after dredging in shallow water near Matuku. The anchorage at Ovalu was surveyed in the beginning of August, on the 12th of which month 1,350 fathoms were reached, 30 miles from Kandavu, the bottom being red ooze. There was little in the dredge but pumice and a branch of a tree.

Between Fiji and the New Hebrides the bottom, on the 15th, in 1,450 fathoms, was red clay. Two days afterwards the same bottom was found in 2,650 fathoms, the temperature being 35° that of 1,300 fathoms. There is proof that below that depth the sea is cut off by a ridge extending towards Raine Island, and from Sandy Cape in Queensland to New Caledonia, New Hebrides, the Solomon Islands, and New Guinea, the depth of which does not exceed 1,300 fathoms. Below this depth, between the New Hebrides and Torres Strait, the water, as in the Mediterranean and other cut off seas, is stagnant.

In a run of 1,000 miles four soundings over 2,200 fathoms were obtained, the temperature constant. At 170 miles from Raine's Island, the depth was 1,700; at 74 miles off, 1,400 fathoms, showing the gentle slope up to the Barrier Reef.*

A continuous line of shallow soundings extends all the way from Torres Strait to the Arrou Islands; some points there are incorrectly laid down on the charts. The sea is shoal—varying from 5½ to more than 150 fathoms on the south-west of Wokan Isle.†

Soundings at 800 fathoms occurred between the Islands, with green mud and rich hauls. The Little Ki group are wrongly placed on the charts. Bird Island is also much out in Horsburgh's Directory; it is a volcano, with a truncated cone 980 feet high, with the slope of 30°.

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*Incidentally, we are informed by Captain Nares, that the squatters on the Gulf of Carpentaria are said to be abandoning their stations because cattle did not thrive well, and sheep not at all. He recommends the retention of Somerset as the best spot for a settlement.

† The town of Dobbo is a dirty place, with population varying, from March to August, from 400 to 1,500, and in November there are only a few Chinese merchants and slaves. In Wamma Island the Dutch have established schoolmasters. Supplies being scanty—poor fowls cost 2s., and eggs 2d. each; fish rare. Three hundred tons of Borneo coal (Tertiary, I believe) were met with.

In 2,800 fathoms the bottom was green mud; it is an enclosed basin, with border only 800 fathoms deep, temperature 37°5, the same as at 900 fathoms. There was found water 600 fathoms deep over the spot marked as Bird Island on the chart.

Leaving Banda, search was made for a reported 4,000 fathoms' sounding; bottom was struck at 1,450 fathoms, ooze, five miles beyond the site, which would give 1 in 2 for a five miles' incline. The conclusion is that the announcement was incorrect.*

The deepest sounding in the Malacca Sea was 1,200 fathoms, with temperature of 35°·2. At 200 fathoms the temperature was nearly the same as on the Equator in the Atlantic, but the surface was warmer.

Between Banka, off the coast of Celebes, and Bejaren, 2,150 fathoms were reached, red clay bottom, 23 miles west of Maquiliere. The Celebes Sea is cut off below 700 fathoms, with a temperature of 38°·6, in agreement with Captain Chimmo's observations. Forty miles from Point Pola, Mindanao, on 22nd October, bottom at 2,600 fathoms, temperature the same as the last, was reached.

At Ilo Ilo the depth was 2,550 fathoms, temperature 50°—same as that reported by Chimmo, and deduced from his observations by Dr. Carpenter. Thirty miles west of Piedra Point, Manila, ooze at 1,050 fathoms, temperature 36°·3, was reached. A deep channel exists between Formosa and Luzon; the temperature agreed with "that obtained by Captain Chimmo; but at the lesser depth of 550 fathoms must have been incorrect." At Manila the air temperature was between 75° and 85°, and oppressive, surface water constant at 82°.

From Commander Tizard's notes, we learn, in addition to the data given in my Address, that the temperatures of the Celebes and the China Seas (the mean distance of which is 8 degrees of latitude) agree well, both receiving their waters from the Pacific (the points of connection with that ocean being, however, respectively 4° N. and 20½° N.) the temperature of both being 45° at 300 fathoms, and 40° at 600 fathoms of depth.

The China Sea is somewhat colder than that of Celebes below 500 fathoms, showing a great circulation from the Pacific Ocean.

The Celebes ridge is stated by Commander Tizard to be 700 fathoms or less (quoted by me from a former document as 400), the China ridge at 900 fathoms, and the ridge between the Celebes and the Sulu Sea at not more than 200 fathoms, and that between the Sulu and China Seas at 170 fathoms. The Banda Sea is considerably higher in temperature than the Celebes; and as the mean latitude of the latter is about 5° N. of the Equator, and of the former 5° S., the temperature of the Banda Sea is governed by

*Whilst at Amboina the Dutch mail steamer, which travels from Sourabaya to Ternate and Banda came well freighted. Coal sold there at £3 4s. 11d. per ton.

that of Arafura rather than by that of the Pacific, the communication being through a series of comparatively narrow channels.

Captain Thomson's Report states that, between the 6th and 11th January, of the present year, on the run from Hongkong to Manila, 2,100 fathoms were reached.

Leaving Zebu a call was made at the volcanic island of Camiguin. Off the south end of Bohol the depth was 370 fathoms. On 26th January the depth, a mile from the volcano, was 190 fathoms, sand and brown mud, with the usual bottom temperature; the height of the volcano being 1,950 feet from a growth of only four years. On 27th, a patch of *six* fathoms was found between the Islands of Aliguay and Mindanao, and on 28th the sounding reached 2,225 fathoms. Leaving Samboanga, 2,050 fathoms were sounded on 8th February; between Meangis and Tulur group, 500 on the 9th; and on 10th and 12th, 2,550 fathoms. On 16th, on the supposed position of the Carteret group (nothing visible at noon at 8 miles clear distance) a depth was reached of 2,000 fathoms.

The following quotation will be interesting to many at the present time:—"Finding we were gradually being set towards the coast of New Guinea, I resolved to call in at Humboldt Bay, and if possible let Staff-Commander Tizard survey it, and also give Professor Thomson and his staff an opportunity of making some researches. We anchored inside Point Caillie on the evening of 23rd February, and shifted further into the Bay on the following morning, anchoring in 35 fathoms, mud. Boats were hoisted out and armed, to begin work, but the menacing attitude of the natives on two occasions determined me to leave the same evening. A stay of a week or ten days would, perhaps, have brought about a good understanding, but with such uncertainty, time, I feared, could not be spared; nor did I consider that the service on which we were engaged would justify an embroilment, and perhaps bloodshed. There were about 100 canoes alongside during the whole day, with from three to six natives in each, but none of them could be induced to put a foot on board, and although trade was carried on briskly the whole time, and in the fairest spirit on both sides, for bows and arrows and other native productions, nevertheless up went their bows on the most groundless alarm, even on the back turn of the screw. Staff-Commander Tizard succeeded in obtaining observations, and in making a partial sketch of the "Challenger" anchorage, which, although deep, is well protected from all quarters."

Captain Nares did not visit New Guinea. He says:—"It was with extreme regret that I found myself unable to afford time to visit any part of New Guinea; even had I been able to do so, very little good could have resulted from a flying visit on only two or three days to a single port."

Captain Thomson was prevented by north-east winds and westerly currents from reaching either the Caroline or Ladrone Islands; but he reached Nares Harbour in Admiralty Island on the 3rd March, got Soundings on the way, and staid there six days finding the natives friendly: a good deal of work was done, and Commander Maclear obtained magnetic observations. On the 10th March they were carried westward, out of sight of both the groups mentioned above. On the 23rd March, the Sounding of 4,475 fathoms was reached, in 11° 24′ N., and in longitude 143° 16′ (not as quoted before by me from a private acount in 145° 16′.) The distance from New Guinea was about 850 miles.

In the same spot, and on the same day, as appears by the Abstract of Soundings, appended to Captain Thomson's Report, a Sounding of 4,575 fathoms was obtained, on red clay. On this occasion one thermometer was broken, and on the second two; the bottom temperature being recordedat 33°·9, and not 35°·5 as in the communication I quoted in my Address.

The difference of the Specific gravities at the surface and at the greatest depth is recorded as between 1·02585 and 1·02592, the pressure increasing, therefore, under a column of water 27,450 feet thick 0·00007, just one-third of what the proportionate increase was two days before, under a depth of 1,850 fathoms, on Globigerina ooze, about 228 miles, a little Westward of North of the position on the 23rd. This is merely a rough deduction of my own, made from the Table of Abstracts.

In the Sulu Sea the Specific gravity was found, on the contrary, to be higher at the surface than at the bottom, increasing upwards 0·00025 in 2,225 fathoms water. Commander Tizard says:—"The Specific gravity of the water in the Celebes, Sulu, and Banda Seas was found to be less than in the Pacific Ocean on the surface; this may be accounted for by the excess of rainfall over the evaporation in the area occupied by them." The temperatures of the seas just mentioned appear to be nearly constant. In the China Sea it is different; the temperatures vary greatly. This is owing to the fact that nearly one-half of the China Sea is under 100 fathoms in depth. Moreover, the China Sea has in winter a range from 64 degrees at Hongkong to 84 degrees at Singapore, whilst the other areas have only slight variations.

"An examination of the chart of the regions mentioned will show," says Captain Tizard, "that the deep basins of the China and Celebes Seas are alone in communication with the Pacific Ocean, and that consequently their temperature must be greatly dependent on the temperature of that part of the Pacific immediately adjacent to their opening into that ocean; for although both seas are in communication indirectly with the Indian Ocean, they are cut off from the deep basin of that ocean by a large tract

of shallow water, which in the China Sea exceeds a breadth of 600 miles, and in the Celebes Sea is apparently about half the length of the Macassar Strait."

These and other collateral facts belonging to the arrangement of the ocean bottom in basins of different depths, and separated by ridges of various widths and extent may, I think, be considered to be in accordance with certain features of the present surface of the earth. On a much smaller scale we have in the Gold Fields of the Lachlan and Currajong a similar conformation,—hollows separated by ridges, in which drift has accumulated, sometimes richly, sometimes poorly auriferous. Since the water that occupies these basins in the Indian Ocean cannot get out to mingle with the neighbouring waters at great depths, we have only to consider that if instead of water the contents of the basins were to be drift matter of various periods, and from various sources, the very features of the gold field alluded to would be explained, inasmuch as some of the deepest drifts have been found of the least commercial importance. This observation will apply to many other gold fields.

There are some interesting data afforded by Commander Tizard, relating to the changes of seasons affecting temperatures of the ocean. At Manila, for instance, in 1870, the total evaporation was 23·7 inches greater than the rainfall, but during the first four months it was 28 inches greater than the rainfall, so that there must have been an excess of 4 inches of rain over evaporation during the remaining eight months. "In 1871 the total evaporation was 32·5 inches greater than the rainfall, and in the first four months 45 inches greater, leaving 12·5 inches in excess of evaporation for the remainder of the year. The mean rainfall at Manila is 95·36 inches." The average rainfall at Labuan is 115 inches per annum, and only an average of 22 inches falls during the first four months of the year; whilst at Hongkong, where the total annual fall is 80·14 inches, 7·77 inches only fall at the same period.

Moreover, the winds affect the changes of temperature, for during the N.E. monsoon the surface water is forced by the wind into the China Sea from a higher and colder latitude, and in the S.W. monsoon the surface water is forced out.

In consequence of these changes and effects, and of the excess of evaporation over the rainfall, "the surface water in the south-west part of the sea becomes heavier and has a tendency to sink, and in sinking carries with it its high temperature, which is gradually imported to the deeper water of the sea.

"The consequence of this is, that in the N.E. monsoon the water in the China Sea has a tendency to sink and *flow out* at the bottom into the Pacific Ocean, whilst in the N.W. monsoon it

will *flow in* and rise to the surface, so that the minimum temperature of the sea during the S.W. monsoon will be nearer the surface than it is in the N.E. monsoon.

"It appears then to be evident that as the China Sea is cut off from the general circulation of the Pacific (the minimum temperature of 36°·1, being at a depth of about 900 fathoms in that ocean), the ridge which separates it from the Pacific is probably between 700 and 1,000 fathoms."

(II.) These observations on temperature and evaporation are most valuable, as will be seen in consideration of another paper to which attention ought to be directed, viz.:—"Summary of Recent Observations on Ocean Temperatures, made in H.M.S. 'Challenger,' and U.S.S. 'Tuscarora,' with their Bearings on the Doctrine of a General Oceanic Circulation, sustained by Difference of Temperature," read in June last, and published in the August number of the Proceedings of the Royal Geographical Society, by William B. Carpenter, M.D., LL.D., Corresponding Member of the Institute of France. Notwithstanding the different conclusions of Professor Wyville Thomson (*see* "Depths of the Sea"), Dr. Carpenter has long been an advocate of the doctrine stated in this summary, and he sees in the facts mentioned in the Reports from Sydney and Hongkong, an abstract of which has now been laid before this Society, a strong confirmation of his views. It will be impossible now to enter fully into his arguments; but those who are desirous of studying them may find their exposition in the memoir named and in his previous papers. But, a few examples of the areas nearest to ourselves may be properly cited here.

In relation to the Antarctic Ocean which the "Challenger" visited, we have these facts. Leaving Kerguelen's Land, and passing some icebergs, she entered the pack-ice in 65° 30′ S. latitude, and on 18th February obtained a Sounding in 65° 42′ S. and 79° 49′ E. Here, says Dr. Carpenter, the superficial stratum was cooled down by the melting of ice several degrees below the substratum on which it is floated. The temperature at the edge of the pack was always between 28° and 29°, just sufficiently warm to melt the salt-water ice very slowly, whilst at a short distance the surface water was found to be at 32°, coming down to 29° at a depth of 40 fathoms, and so continuing to 300 fathoms, the depth at which the icebergs float. Below this there is a temperature of 33° or 34°, and again a deep stratum below of glacial water. Captain Nares thought the bottom temperature would be 31°; but Dr. Carpenter had met with a bottom temperature of 29°·5 in the Faroe Channel, in the Atlantic, and therefore thinks 29°. nearer the mark. "The notion" (he says) "that in

Polar seas the temperature goes on increasing in depth till it reaches 39° may now be disposed of." He attributes that notion to the effect of pressure on the thermometers used by D'Urville and Sir James Ross. He argues that the warmth of the sub-surface stratum can have no local source. Captain Nares found, between 13th and 25th February, a slightly colder climate in 64° S. latitude than is found in August in the Arctic seas in 74° N.; and Dr. Carpenter argues from this that, as the atmosphere in the winter tends to keep down the surface warmth, the temperature of from 30° to 34° must have come from a lower latitude, and Nares regards it as "evidently the continuation towards the cold regions of the main oceanic flow of water." Dr. Carpenter sees that, as there is no "Gulf Stream" in the Antarctic area, the warm water of the underlying stratum shows the tendency of the upper stratum to the Pole, which is the result of indraught produced by the downward movement in the Polar area by the effect of surface cold. Any interruption of this descent is purely local and temporary, being limited to the margin of the ice-region in a brief summer season.

Dr. Carpenter considers the passage of the "Challenger" from the Antarctic ice to Melbourne peculiarly instructive, especially between 58° 55′ S. and 108° 35′ E. and Cape Otway, in 38° 50′ S. and 143° 37′ E. On the 3rd March, at the former position, the surface temperature of 37°·2 was gradually reduced to 36°·6 at 60 fathoms; then to 33° at 70 fathoms; the temperature from that to the bottom, in 1,950 fathoms, being 31°, only 2° lower. In the next sounding, on 7th March, in 50° 1′ S., and 123° 4′ E., the surface being at 45°, the Isotherm of 40° was found to be at 250 fathoms, and that of 35° at about 1,000 fathoms; the bottom at 1,800 fathoms, being 32°·5. On 10th March, in 47° 25′ S., the isotherm of 45° had sunk to about 450 fathoms, that of 40° to about 600, and that of 35° to 1,350; the bottom being, in 2,150 fathoms, at 33°·3.

As the Australian coast was neared, the temperature of the surface gradually increased. Comparing this with the sections in the Southern Indian Ocean and the South Atlantic under nearly the same parallels, the thickness above the isotherm of 40° is noticeable, but especially so in the stratum between 45° and 50°, which thus corresponds with the stratum between 55° and 60° in the western portion of the North Atlantic under corresponding parallels. This Dr. Carpenter considers to be due to "an extension of the *East Australian current*, which is the southward prolongation of the southern portion of the Pacific Equatorial."

We are thus brought face to face with the effects of the current which sets southwards along our coast, frequently with rapidity, between Moreton Bay and Cape Howe, and by which,

on 21st May, 1839, the ship in which I arrived here was carried 46 miles to the south in twenty-four hours, about 25 miles from the land, the depth at noon being 70 fathoms.

On the "Challenger's" passage from Melbourne to Sydney, while the surface temperature rose to above 70° the cold understratum rose nearer to the surface, the isotherm of 40° lying at about 400 fathoms, and the descent nearly uniform. But from Sydney to Cook's Strait, in New Zealand, while the surface temperature fell with increase of the distance from the Equator, the isotherm of 40° again deepened to more than 700 fathoms, the stratification above being nearly uniform. On the way to Fiji, as the surface temperature increased, the isotherm of 40° again rose to within 450 fathoms from the surface. Comparing these observations with those recorded of the Equatorial Atlantic, to which Dr. Carpenter had already drawn notice last year, in his paper headed "Further Inquiries," he thinks "*it may now be stated, with some confidence, that the lightening of the upper stratum by elevation of its temperature tends to favour the ascent of cold water from the bottom, which is precisely what theory would lead us to anticipate.*"

He further states that the soundings taken by the "Challenger" in different parts of the Eastern Archipelago confirm this view, and in illustration he quotes a passage which I have to-night already referred to, from Captain Nares, relating to the shallow bank of 1,300 fathoms, between Sandy Cape (Queensland), New Caledonia, and New Guinea. He deals with the other cases I have also quoted, and comes to the same general conclusion, confirmatory, as he believes, of his opinion that currents *are due to the interchange of temperatures.*

He argues, in dealing with the results of the observations made on board the "Tuscarora," that if the action of the Gulf Stream in the *cul de sac* of the northern Atlantic (that stream being a *mere rivulet*) is capable of producing the downward displacement of colder water (which Professor Wyville Thomson suggests as a *vera causa**), "much more ought that effect to be produced in the North Pacific by the Japan current, which has no outlet at all save the narrow and shallow strait of Behring." But it may be mentioned that the depth of Behring's Strait is only 32 fathoms; and it may be asked how could an Arctic current only 192 feet deep affect the water in the enormous depression of the North Pacific,

* It is well to mention that Professor Wyville Thomson, who was with Dr. Carpenter in the first explorations of the Atlantic, holds views not in exact agreement with those of his companion. These are deserving of full consideration, and are freely stated in his work on the "Depths of the Sea," in chapter viii of which work the Gulf Stream is freely discussed. See pp. 397-398.

which the "Tuscarora" sounded to nearly 28,000 feet, or how otherwise are we to account for the deep stratum of Glacial water in the North Pacific (seeing there can be no fresh connection with the Arctic Ocean), except by the fact that the Antarctic cold water finds its passage northwards all the way past Kamschatka over the deep sea bottom of the Pacific.

Some very striking facts are related of the depths and bottom-contour of the North Pacific. By sections, on eight lines of soundings, between San Francisco, Cape Flattery, and San Diego, it seems that there is a great similarity in the contour of the bottom and that determined along the western shores of Europe, falling gently and then steeply, as on the west coast of Ireland, with terraces between deep depressions. In the more southern area at 150 miles from San Diego, the depth was 2,117 fathoms, and for nearly 1,000 miles westwards it varied between 2,049 and 3,604. About half way to the Sandwich Islands, where it is 2,159 fathoms deep, the bottom sinks rapidly to 2,650, and then to 3,000 fathoms; and about 150 miles from Honolulu it rises to 2,488, falling near the Sandwich Islands to 3,023, where they spring from that enormous depth, which exceeds that at the base of the Atlantic Volcanic Islands very considerably.

Within 50 miles of Hawaii, the water deepens from 206 to 1,580 fathoms, and within 100 miles, to 2,418 fathoms. The American half of the North Pacific is, however, more regular than the Asiatic.

Westward of Honolulu, the bottom varies from 1,874 falling to 3,045 fathoms, and for more than 300 miles continues at about 3,000 fathoms; then at about 1,400 miles west of Honolulu it comes to 1,108 fathoms from the surface. To the eastward the depth increases to 3,262, and keeps nearly the same till 2,275 miles from Honolulu, where it rises abruptly from 3,009 to 1,400, then falls to 3,023; and so, by alternate abrupt elevations and falls, from 3,000 to 1,500 and 2,173 fathoms.

The bottom between San Diego and Honolulu consisted of yellowish brown ooze, with fine sand; but in the shallow portions near the Hawiian Islands, of "whitish-grey sand," apparently disintegrated coral. To the westward, also, the yellowish-brown ooze was uniformly found, but at certain points white coral with lumps of lava, whitish-cream coloured ooze at 1,964 fathoms; at 1,108 and 1,817, white coral; at 1,613, white coral and sand, and at 2,813, the yellowish-brown ooze. At 2,092 and 2,173 fathoms coral limestone and sand appeared; at another point, at 1,499 fathoms, coral limestone with specks of lava; at another, at 1,712 fathoms, coral limestone and sand; at a third, at 1,700 fathoms, coral limestone and lava; and on both slopes of Peel Island in the Bonin Group, coral limestone and lumps of lava.

From these data Dr. Carpenter infers that between the Sandwich Islands and Japan there must have been "a great and rapid subsidence within a very recent epoch." This, is, no doubt, a just conclusion, for, as he states, the limit of coral growth being about 20 fathoms, the seven elevations in the area named show that the sinking was too rapid to allow of the corals being formed up to the surface in the period of depression. The corals must have been killed at the submersion of each elevation, as on the slopes of the Bonin Islands. It is a fair illustration of Darwin's and Dana's doctrines of the coral reef formations; and the data also show that there was once a chain of submarine volcanoes in that part of the Pacific. The absence, moreover, of such coral islands, as in the Central and Southern Pacific, shows also the rapidity and perhaps recentness of the subsidence in the Northern portion. I would remark, however, that this must have taken place very recently indeed, if the view taken is correct, that the volcanic islands lie along a line of elevation.*

The great depth of the bottom in parts of the Pacific will, as Dr. Carpenter deduces from the Tuscarora observations, render the laying of a cable across that section unsuitable. The irregularity of the bottom is also very great near the shores of Niphon, Yesso, and the Kurile Islands, though a terrace exists at from 1,100 to 1,425, and 653 fathoms of depth; for at the outside of the ridge the fall was rapid to 3,587, 4,356, and 4,655 fathoms. Even 100 miles south of Cape Lopatka, the extreme point of Kamschatka, the depth was 3,759 fathoms; and though it rose at about 300 miles south of Behring's Island, to 1,777 fathoms, it sank again rapidly to 4,037. Similar facts are stated of the vicinity of the Aleutian group. South of the Alaskan Peninsula, great and sudden changes of depth occurred; but between 53° 35′ N., and 60° W., and Vancouver's Island, for 1,000 miles, the bottom sloped upwards with little variation from 2,500 to 1,500 fathoms, and after another series of ups and downs from 1,007 to 1,300, it rose to within 100 fathoms along the North American coast. Yellowish and clay-coloured mud and ooze with grey and black sand, formed the specimens brought up, but in one spot, at 3,439 fathoms, the bottom was formed of "hard yellow sand with black specks." Dr. Carpenter ends his review of the "Tuscarora's" researches in these words:—"Along the whole of this route, except between the Peninsula of Alaska and Cape Flattery, there was land at no great distance; and there is therefore no great difficulty in supposing that both the mud and sand were derived from its disintegration. No indication is given of organic constituents; but I have reason to believe that a microscopic examination of these Soundings would yield abundance of siliceous exuviæ."

*See on this head some interesting remarks by Darwin (*Structure and Distribution of Coral Reefs*, 2nd. Edn., 1874, p. 184).

I trust it is not necessary for me to explain that, in again bringing this subject before the Society, my chief object has been to lay before its members the interesting details of the great experiment now going on as to the ocean bottom, so far as it is within our reach; and if I have drawn largely from Dr. Carpenter's paper, I owe no further apology for so doing than the quotation from the words of the President of the Royal Geographical Society, at the close of the reading, with which I will conclude this part of my remarks.

"The President said that, upon such papers as that which Dr. Carpenter had prepared, the scientific reputation of the Royal Geographical Society amongst continental nations depended. If it was merely a Society to register personal adventures or the ordinary run of travellers, it might be a Geographical Society, but it would not be a Scientific Geographical Society. When, however, serious problems of physical geography, such as Dr. Carpenter had solved, were considered, the Society fulfilled those functions for which it was really constituted."

If I may apply this to ourselves, I would say that, in making known to all our members, and to outsiders in the Colony at large, information of the kind condensed in this paper (though in one sense not strictly original), I have considered that I have been carrying out part of the work for which we have been united; for if the researches as to the formation of Australasian lands, or of the starry worlds above us, be of use in the education of a people, so the wonders of the ocean, and what we can learn of its depths, are equally part of the aim we have in view; and surely we ought not to exclude the sea that washes our shores with its currents, offering as it does prospects of intercommunication by means of its bottom, from what belongs to the development of "The resources of Australia."

III. One other brief portion remains in connection with the subject before me. Many facts were cited in my Anniversary Address relating to the occurrence of Globigerina ooze and the tiny creatures from which that designation is taken. There are many notices also of the Red clay. These were principally from the observations of Professor Wyville Thomson. That distinguish naturalist has recently thrown fresh light on these subjects. In a letter, dated Yeddo, 9th June, 1875, he addressed to Professor Huxley some very interesting information respecting living Globigerina; and the latter gentleman has communicated it to the readers of *Nature* in the Number of that journal for 19th August (vol. xii. p. 318).

Professor Thomson, in a note recently published in the "Proceedings of the Royal Society," had stated that up to that time he had never seen any trace of the *pseudopodia* of Globigerina.

He says—"I have now to tell a different tale, for we have seen them very many times, and their condition, and the entire appearance and behaviour of the sarcode are, in a high degree, characteristic and peculiar." He then states that when at once transferred from the tow-net to a tolerably high-power microscope, in fresh, still sea water, "the sarcodic contents of the chambers made be seen to exude gradually through the pores of the shell and spread out until they form a gelatinous fringe or border round the shell, filling up the spaces among the roots of the spines, and rising up a little way along their length."

"This external coating of sarcode is rendered visible by the oil globules, which are oval and of considerable size, and filled with intensely coloured secondary globules; they are drawn along by the sarcode, and may be observed with a little care following its spreading or contracting movements. At the same time, an infinitely delicate sheath of sarcode containing minute transparent granules, but no oil globules, rises on each side of the spines to its extremity, and may be seen creeping up one side and down the other of the spine, with the peculiar flowing movement with which we are familiar in the pseudopodia of Gromia and of the Radiolarians."

"If the cell in which the Globigerina is floating receive a sudden shock, or if a drop of some irritating liquid be added to the water, the whole mass of protoplasm retreats into the shell with great rapidity, drawing the oil globules along with it, and the outline of the surface of the shell and of the hair-like spines is left as sharp as before the exodus of the sarcode."

Dr. Thomson then states that in the Atlantic, the siliceous bodies, such as spicules of sponges and of Radiolarians or the pustules of Diatoms found in the Globigerina ooze appeared to diminish in the transition to the red clay. His recent observations have served to correct that opinion, and singularly enough the fresh data were obtained from the greatest depth reached in the Pacific, that of 4,575 fathoms, on the 23rd March (already referred to), between the Caroline and Ladrone groups, when one of the thermometers resisted the pressure, as Dr. Carpenter remarks, "of six tons to the square inch." Professor Wyville Thomson says the bottom was rather different from the ordinary red clay, being more gritty—"the lower part of the Sounding-tube seemed to have been compacted into a somewhat coherent cake, as if already a stage towards hardening into stone." It appears also that, at such a depth, the deposit assumes "the character of an almost purely organic formation, the shells in this case being siliceous," whilst at about 3,000 fathoms the calcareous element was prominent. Another fact is inferred—that "Radiolarians exist at all depths in the water of the ocean, while Foraminifera are confined to a comparatively narrow belt."

Further it is suggested that fresh species are found as the depth increases, and in increasing numbers, and of larger size; and that if the depth be enormously increased the red clay must be swamped, and masked by the Radiolarian shells.

These references are necessarily limited; but enough has been quoted to excite surprise at these revelations respecting the inhabitants of the ocean, and at the marvellous fact that creatures so minute can exist and carry on the functions of life under such pressure as they must be subjected to.

Professor Huxley, in his communication to *Nature*, admits that Professor Wyville Thomson and his Staff have not been able to discover what he calls *Bathybius*, and that it is "seriously suspected" that the said *Bathybius* "is little more than sulphate of lime precipitated in a flocculent state from the sea water by the strong alcohol in which the specimens of the deep sea soundings which he examined were preserved."

Much to his credit, Dr. Huxley adds:—"Since I am mainly responsible for the mistake, if it be one, of introducing this singular substance into the list of living things, I think I shall err on the right side in attaching even greater weight than he (Professor Thomson) does to the view which he suggests."

As many persons do not know what was meant by the term *Bathybius*, it may be instructive to quote a passage or two from Professor Wyville Thomson, who thus describes it in "*The Depths of the Sea,*" p.p. 409–415.

"The dredging at 2,435 fathoms at the mouth of the Bay of Biscay gave a very fair idea of the bottom of the sea over an enormous area, as we know from many observations which have now been made, with the various sounding instruments contrived to bring up a sample of the bottom. On that occasion the dredge brought up about $1\frac{1}{2}$ cwt. of calcareous mud."

* * * * * * *

"In this dredging, as in most others in the bed of the Atlantic, there was evidence of a considerable quantity of soft gelatinous organic matter, enough to give a slight viscosity to the mud of the surface layer. If the mud be shaken with weak spirit of wine, fine flakes separate like coagulated mucus, and if a little of the mud in which this viscid condition is most marked be placed in a drop of sea water under the microscope, we can usually see, after a time, an irregular network of matter resembling white of egg, distinguishable by its maintaining its outline and not mixing with the water. This net work may be seen gradually altering in form, and entangled granules and foreign bodies change their relative positions. The gelatinous matter is therefore capable of a certain amount of movement, and there can be no doubt that it manifests the phenomena of a very simple form of life.

"To this organism, if a being be so called, which shows no trace of differentiation of organs, consisting apparently of an amorphous sheet of a protein compound, irritable to a low degree and capable of assimilating food, Professor Huxley has given the name of *Bathybius Haeckelii*."

If this have a claim to be recognised as a distinct living entity, exhibiting its mature and final form, it must be referred to the simplest division of the shell-less *Rhizopoda*, or if we adopt the class proposed by Professor Haeckel, to the Monera.

"The circumstance which gives it special interest to Bathybius is its enormous extent; whether it be continuous in one vast sheet or broken up into circumscribed individual particles, it appears to extend over a large part of the bed of the ocean; and as no living thing, however slowly it may live, is ever perfectly at rest, but is continually acting and re-acting with its surroundings, the bottom of the sea becomes like the surface of the sea and the land—a theatre of change, performing its part in maintaining the 'balance of organic nature.'

"Entangled and borne along in the viscid stream of *Bathybius*, we so continually find a multitude of minute calcareous bodies of a peculiar shape, that the two were long supposed to have some mutual relation to one another.

"These small bodies which have been carefully studied by Huxley, Sorby, Haeckel, Carter, Gumbel and others, are in shape like oval shirt-studs. There is first a little oval disk about 0.01 m.m. in length with an oblong rudely facetted elevation in the centre, and round that, in fresh specimens, what seems to be a kind of frill of organic matter, then a short neck, and lastly a second smaller flat disk, like the disk at the back of a stud. To these bodies which are met with in all stages of development, Professor Huxley has given the name of 'coccoliths.' Sometimes they are found aggregated on the surface of small transparent membranous balls, and these which seemed at first to have something to do with the production of the 'coccoliths,' Dr. Wallich has termed 'coccospheres.'" * * * *

"I think that now the balance of opinion is in favour of the view that the coccoliths are joints of a minute unicellular alga living on the sea surface and sinking down and mixing with the sarcode of *Bathybius*, very probably broken into it with a purpose, for the sake of the vegetable matter they may contain, and which may afford food for the animal jelly. What the coccospheres are, and what relation, if any, they have to the coccoliths, we do not know." * * * * * * * *

"I feel by no means satisfied that *Bathybius* is the permanent form of any distinct living being. * * * * *

"I think it not impossible that a great deal of the '*Bathybius*,' that is to say the diffused formless protoplasm which we find at great depths, may be a kind of mycelium—a formless condition connected either with the growth and multiplication or with the decay—of many different things."

[The term "Monera" in the above extract means a class formed by Prof. Haeckel (*Biologische Studien*, *Leipzig*, 1870) for "a vast assemblage of almost formless beings, apparently absolutely devoid of internal structure, and consisting simply of living and moving expansions of jelly-like protoplasm." (*Vide* "*Depths of the Sea*," p. 408.)

The Monera are the first-class in the first and simplest of the invertebrate sub-kingdoms,—the Protozoa; the other two classes being the Rhizopoda and the Sponges. Of these, says Professor W. Thomson (*op. cit.* p. 409), "The Monera pass into the Rhizopoda, which give a slight indication of advance, in the definite form of the graceful calcareous shell-like structures which most of them secrete, and the two groups may be taken together."]

FACTS IN AMERICAN MINING.

By S. L. Bensusan, Esq.

[*Read before the Royal Society*, 2 *June*, 1875.]

In this paper I propose to call attention to what has been done in America, in the way of improvements in methods and processes of mining—in the improved apparatus and appliances employed—to give data showing the great results achieved with material and by processes with which we are comparatively unacquainted—point out some of the conditions in which gold, silver, and other metals are found and worked—give sketches of some of the great works undertaken, and their results—and, generally, any other matter that may present itself worthy of note and believed to be not generally known. Whilst endeavouring to confine myself as much as possible to new matter, I doubt not that many will find in the paper material with which they were previously acquainted, a circumstance unavoidable in any case.

Some years since, the American Government appointed a Commission to investigate and report upon the condition of the mining industry in the Western States of America; to this report I am indebted for much of the material in this paper. The report of the Commission contains not only many facts of great scientific interest, but so many valuable inferences are deduced, and such a thorough acquaintance with the subject is displayed, that there is little left to be done beyond culling the matter of interest and presenting it in a useful form.

For convenience of reference the subject will be divided under the following heads, viz.: 1. Mode of occurrence. 2. Methods of mining. 3. Treatment of metals. 4. Statistics. In the present paper I shall deal only with gold and silver.

Mode of occurrence.

Gold, silver, and an alloy of these metals, occur in quartz reefs, frequently largely mixed with copper, lead, zinc, antimony, arsenic, iron, sulphur, &c.

Loose slate.—Near Sacramento and elsewhere large bodies of loose slate occur, containing pyrites. The material is soft, and eight tons per day are crushed with each stamper. The value of the yield is only 20s. to 25s. per ton, but such is the supposed value of such property that half-interest in the Sacramento mine was sold for £35,000.

Cement.—This material is crushed very coarse, passing through a mesh of 8 to 16 holes to the inch, and a light stamper will crush 4 to 6 tons a day.

Sea-sand, arising from the detritus of quartz reefs.—There are cases in which the working of this material have been profitable.

Ancient river beds—in some places a thousand feet deep. One of the largest of these occurs in the Sierra Nevada country, having a width of 100 to 300 yards, and a length of nearly 40 miles. The amount of gold taken from this bed has never been ascertained, but cannot be less than five millions sterling, and probably twice as much. The modern streams run at right angles with the ancient river bed. On the Tuolumne Table Mountain the basalt was found to cover an ancient river bed to a depth of 300 to 1,000 feet. After years of work the channel was reached, and ten feet square of washdirt yielded £20,000; a pint of gravel not unfrequently containing a pound of gold.*

The auriferous belt in California extends about 250 miles in length, with a width ranging from 25 to 50 miles. The veins in this belt are innumerable—but the proportion producing payable gold is very small; the average width of all the veins examined is about three feet, and the "country" rock either slate, granite, or greenstone, but the most prolific of these formations is still undetermined. The mines frequently possess barren zones, both in depth and longitudinal extension, but as frequently "make" again in paying ground.

* Ancient river beds.—In this country we have an ancient river bed at Kiandra and the vicinity, on the main Dividing Range; the wash is 5 to 10 feet thick. The bed was originally a river-wash, but it has become in places partially cemented with oxide of iron. It consists partly of quartz, some of which is highly impregnated with copper. Single boulders of quartz have been met with producing nearly a hundred pounds worth of gold. The rest of the wash is made up of brecciated fragments of quartz, called by the miners "floating reef," also slate, diorite, albite, felspar, hornblende, augite, &c. The average yield has scarcely been ascertained as yet, and the bed of the ancient stream has not yet been reached. This river bed has been traced about 30 miles, and again comes out in the Snowy Plains, in Victoria, where the Government intend to bore for, and prove it. A body of four men owning what is known as the Scotchman's claim, at New Chum Hill, Kiandra, have driven into the hill a distance of 1,300 feet, and now find that the wash has dipped away beneath them; they have already been ten years at work here, occasionally tapping some part of the wash overhead. The total distance they have driven in all is about 2,300 feet, illustrating an extraordinary case of perseverance under difficulties and privations in a most severe climate. This run of partially cemented wash appears to have followed the main range, thus showing the great alteration of the surface since its deposition. It is considerably above the level of the surrounding country, and about 5,000 feet above the sea level. The bed rock of the country at New Chum Hill is a mica slate, and strongly stained with oxide of iron. Just above the deposit of wash is a bed of grey clay, about 12 feet in thickness; above that a 30-feet bed of lignite; above that a bed 6 feet of clay—over the clay various layers of waterworn gravels, capped by basalt, estimated to possess a thickness in some places of 500 feet. It is estimated that this basalt covers a larger auriferous area than all the known Gold Felds in New South Wales put together, though it is but little known at the present time. Starting from Snowy Plains, it comes out at Kiandra again on the Macquarie, through Mount Misery, on the Rocky River, still following the main range; lastly we hear of gold under basalt on the Palmer, still on the main range, while it is not improbable that it will be met with in New Guinea. Both the basalt and the wash on the main Dividing Range, as well as the gold itself, appear to be different in character from all other alluvial beds in the Colonies, and point to their deposition in an earlier epoch. Most of the gold is coarse, some being found in nuggets of one to two ounces, very little waterworn, and largely alloyed with silver, its value being only about £3 12s. 6d. per ounce. It is probable that many places will be found auriferous along this range where the conditions are similar to those above described.

The Eureka Mine, Amador County, furnishes some curious and interesting facts, in a measure subversive of certain recognised geological dogmas. It is commonly believed that the yield of gold must decrease in depth; but in this mine the value of the yield for the first thirty feet was only 30s. to 60s. per ton, barely sufficient to pay expenses. Below that level it rose from 56s. to 84s.; at 100 feet it yielded £5 12s., at 200 feet, £7 4s., and at 300 feet it attained a yield of £12 per ton. From this we may learn some important lessons. It shows that we must not apply scientific dogmas in all cases; that because the surface is poor, the mine must be unworthy of trial or necessarily poor in depth. This mine yielded in one year a profit of £75,000, and has attained a depth of 1,200 feet. It is a noticeable feature that it exists at the junction of slate and greenstone, the latter being hard and compact, and forming the hanging wall; while the footwall is composed of a soft argillaceous slate. To the junction of these two formations is ascribed much of the success of this mine, and the continuity of the gold in depth, while the soft character of the footwall has enabled the mining to be conducted at small cost. The opinion that quartz veins grow poorer in desending appears to be unsupported by sufficient evidence, but there are a number of circumstances calculated to lead the superficial observer to that conclusion; one of these is found in the fact that as the portion of the reef exposed to atmospheric influence gets weathered, it is necessarily accompanied by the degradation of some of the quartz, in most cases leaving the gold; the capping is therefore not a fair sample of the quartz in the immediate vicinity; then again, every reef varies in richness in different portions of its length and depth, and a prospector would be most likely to select from the richest portions showing on the surface. Moreover, the gold almost invariably exists in bunches, shoots, or chimneys, which cut the axis of the vein horizontally, or vertically, at all angles. Not unfrequently the gold will be on one or other of the walls for a

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On the West Coast of New Zealand, a cemented sea-sand of quite a different character is met with and worked for gold; it is conglomerated with iron, and such is its hardness that, though usually removed by the use of a gad, it has frequently to be blasted with powder. It is unmistakeably a sea deposit, being left bare by the receding sea, as the land has gradually risen. It is crushed in the ordinary way, and leaves large dividends, with a yield of only 1 dwt. per ton. The gold occurs in distant leads, parallel to the sea-coast; they vary from 20 to 50 feet in width; all the rest is barren, in the intervening space between these leads. Their direction is so true that the diggers follow them for miles by compass, frequently cutting their way through the bush for considerable distances, to pick up the precise point indicated by the needle, and seldom mark out a claim anywhere outside of the line. Far back from the water's edge there are a series of these leads, all preserving their parallelism for miles. The operation known as "haymaking" consists in collecting the sand thrown up by the spring tides, consisting largely of titaniferous iron, with loose gold visible to the eye, on walking over it. This is removed, and afterwards treated by running through a box. It is a remarkable fact that all the gold leads on the West Coast partake of the same character of parallelism, and are evidently deposited in the same way. It is, however, believed that the gold is originally carried down by the river running at the back of the range. To show the changes taking place in the level of the land, there may be seen on the West Coast of New Zealand, South of Hokitika, and nearly half a mile back from the sea, the remains of an old whaling vessel surrounded by thick scrub; some part of the hull is still in a good state of preservation, and where the mast once stood, now grows one of the monarchs of the forest.

certain distance, while all the rest of the reef is barren. Where several parallel reefs are found near each other, one may be rich in gold for a considerable distance while all the others are barren, and when the gold suddenly dies out it will not unfrequently be found to commence in a parallel reef, but at a spot at right angles with the point at which it has ceased in the previously producted reefs. This phenomenon has been observed at Hawkin's Hill in this Colony. In the same way that a chimney or shoot of gold will be found to pass diagonally along a reef, leaving barren or poor ground above and below, it not unfrequently happens that other and sometimes richer shoots of gold are met with at greater depth, having a certain parallelism to the first shoot.*

Though soft and easy ground are most favourable for mining exploration, it must not be supposed that payable mines only exist under such conditions. In the Grass Valley the best mines are found in a hard metamorphic slate, and the most productive have generally been the narrowest. The production of gold from this region has not been far short of five millions sterling; and in the best mines here the vein has rarely exceeded a foot to fourteen inches. The size of the vein and character of the rock must not therefore be looked upon as an infallible guide in the selection of a claim.

In regard to the peculiar distribution of gold, it is to be regretted that science has done so little as yet to guide us in its search; but the next best guidance we can have, when the light of science is wanting, appears to be in the accumulation of such facts as may warrant us in drawing some general deductions, in the information afforded by extensive experience, and in the wide publication of results obtained from such experience. In mining generally it may be admitted that much success is due to adventitious circumstances, but it is not the less true that we may derive much benefit from the experience of others, both in knowing where reasonable hope of success may attend the employment of capital, labour, and skill, and not less where the waste of energy and skill may be averted.

One illustration of the peculiar way in which gold occurs may be given by reference to the Sierra Buttes Mine, where the vein, which is enclosed in hard metamorphic slate, varies in width from 6 to 30 feet; the portion nearest the footwall only is productive, and its average width, about 12 feet, alone is removed; here at 750 feet the mine is as productive as at the surface.

The different minerals found in the Western States occupy particular zones and belts, which are for the most part well marked; most of them follow the general course of some mountain chain, or run in series of nearly parallel belts. The copper-bearing belt is principally in serpentine—other magnesian rock, or metamorphic

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* The existence of gold on one side of the reef has been noticed in Gippsland, Victoria, and elsewhere. In New Zealand it is very marked, at Heape's Creek, Thames Gold Field.

slate. The gold-bearing belt, east of the copper belt, is characterised by quartz ledges traversing slates, limestones, sandstones, and granite. Crossing the crest of the Sierras we come into regions where the gold is alloyed with silver, and further east it is entirely replaced with silver, associated with copper, antimony, and arsenic —all the metals and minerals being pretty distinctly characterised in their distribution by the nature of the rocky strata and condition of metamorphism.

The age of the gold-bearing rocks in California has not been determined, but a considerable portion are distinctly carboniferous. In the coast mountains gold is found in close proximity to rocks of a tertiary age; and the fact of gold being occasionally found in cinnabar-bearing formations, leads to the belief that it is even as recent as the miocene (or middle tertiary), in opposition to existing views.

Professor Silliman records the examination of some mines in the neighbourhood of Fredericksburg, and states that the gold-bearing quartz usually exists in talcose and mica slate; that in the greater number of cases the eye discerns no gold, though sulphides of iron, zinc, and lead are often seen. In the Moss Mine, quartz which yielded gold to the value of £20 to £40 per ton showed no sign of gold, even with a magnifier, thus proving that we cannot judge of the gold-bearing capabilities of quartz by the sight. In the Walton Mine a more notable instance of this occurred—firm and compact quartz, interspersed with iron pyrites and dark iron ore, gave on first trial £16 per ton, second trial £32, third trial £80, fourth trial over £500 to the ton; but in the first three trials gold was *not* visible to the eye.

Professor Rogers ascertained that the talcose rock underlying a quartz vein was itself gold-bearing to a depth of 6 inches. What other rocks enclosing gold-bearing veins are also auriferous, and to what extent, we have still to learn. *

The distribution of metallic wealth in Western America occurs as follows, viz:–In Pacific Coast Range on west, occur quicksilver, tin, and chromic iron. In Sierra Nevada belt on west slope there are two zones; the foot hill chain, copper mines; a middle line of gold deposits east of this line; and the east base of Sierra Nevada, striking into Mexico, silver mines with but little base metal.

Through New Mexico, Arizona, Middle Nevada, and Idaho, another line of silver mines exists, with complicated association of base metals.

Through New Mexico, Utah and Western Montana, argentiferous galena lodes.

To the east again, the New Mexico, Colorada, Wyoming and Montana gold belt is exceedingly well defined.

* At the Caledonian Reef, in New Zealand, the footwall adjacent to the shoot of gold was itself found to be gold-bearing for a thickness of 15 feet, that portion of the enclosing rock having been crushed with profit.

The Comstock lode lies at the junction of syenite and propylite, occupying the contact plane, along the entire front of the Davidson Range; in places north and south it is entirely walled by propylite; this rock is a species of greenstone, being composed of oligoclase and hornblende.

Methods of Gold-mining.

Hydraulic mining is in great favour in California, but in New South Wales its existence is hardly known. Immense works are undertaken by the enterprising Americans for carrying on this method of mining on a large scale, and hundreds of thousands of pounds have been expended in bringing large bodies of water from distances of 30 or 40 miles for the purpose of washing away whole hills to get at the ancient river beds below containing the gold. In the Blue Gravel Company's claim a tunnel of 1,700 feet had to be cut to ascertain if the ground was payable, in some cases costing £20 per foot. After five years of hard labour the Company had spent £20,000 and were still without any certainty of finding gold.

They now use 500 inches (miners' measurement) of water, equal to a stream of 3 feet wide and 8 inches deep, running at high velocity. They consume over 60 tons of powder annually in loosening the ground, and 3 tons of quicksilver at a time to catch the gold. This Company pays £15 per day, or about £5,000 a year, for the water supplied to them.

To give some idea of the magnitude of the waterworks, I may here mention that the Eureka Company constructed 250 miles of race, at a cost of over £180,000. This Company's receipts for water used, at one time, to be a thousand pounds per day. In 1867 there were no less than 6,000 miles of canals or races in the Western States.

A very ingenious device for carrying water long distances and avoiding circuitous detours in hilly country has been adopted by the introduction of inverted syphons, for carrying water up the sides of hills, by the heavier pressure of a column brought down the opposite slope.

Sluices of great magnitude have been constructed for gold-washing, and in cases where the gold is fine they have been constructed over a mile long; and ground sluices where large bodies of washdirt had to be treated by rapid and inexpensive processes. Few persons unacquainted with this description of gold-mining have much idea of the small quantity of gold that may be made to pay in ground sluicing, with a good head of water. At a small claim on the Shoalhaven, in this country, a cubic yard of earth containing six pennyworth of gold pays wages, and leaves a profit for dividends; and in this particular claim I have washed out payable gold below the tail race, a mile from the spot it was washed from.

The gold-dredging machine has perhaps never been heard of except in California; but it is an actual fact that such a machine was constructed, and used on the Yuba River, the bottom of which was very rocky and rugged, and the machine proved a failure.

The arrastra is too well known to need any remark, except that material that would not yield gold to the value of £15 per ton could not be treated by this apparatus at a profit.

The tom, rocker, the sluice, and hydraulic mining have been made the subject of instructive comparative experiments as to their capabilities; and it has been shown, after careful investigation, that with the tom one man might wash 1 cubic yard of earth per day; with the rocker one man might wash 2 cubic yards of earth per day; with the sluice one man might wash 4 cubic yards of earth per day; with the sluice and hydraulic one man might wash 50 to 100 cubic yards of earth per day.

It is not unusual to use two tons of powder at a blast in some of the large hydraulic claims.

Flumes of great magnitude have been erected in different parts of the States—one to drain the Feather River, at Oroville, cost £35,000, and yielded a profit of £15,000 the first year, but subsequently proved an unprofitable undertaking.

The Frieberg German Barrel and Mexican yard, or Patio processes (which will require no description here) were the principal processes employed for the extraction of silver from its ores; but these are gradually being supplanted by the iron pan.

The Sutro Tunnel.—Among the most remarkable works of magnitude in mining being carried out in the State, one of the foremost is the Sutro tunnel. It is to extend a distance of three and three-fifths miles, and draw the Comstock lodes to a depth of 2,000 feet, and will cost, when completed, one million sterling. The Companies on this great lode have agreed to pay a certain sum on every ton of ore raised from the mines on completion of the work. On the 1st November 1874 the tunnel had been driven 7,792 feet. During three weeks in October the tunnel was driven 80 to 83 feet per week; the last week in October, 116 feet. The size of the tunnel is 10 × 14, and in one month 360 feet had been driven by the Burleigh drill, being the heaviest work of this kind on record. Comparing this work with some of our Australian mining, we will take, by way of example, the adit driven into the Belmore Mine, on the Great Western Company's property, near Icely. The size of their adit is 6 × 4½, and in eighteen months they have driven 480 feet. This gives 6·31 lineal, or 170 cubic feet per week, while the Sutro tunnel, 116 × 10 × 14, gives 16,040 cubic feet, or nearly ten times the work in a given time. In the Hoosac tunnel the average progress under the old system was 49 feet per month. The work performed with the drills was at the rate of 150 feet per month, at a greatly reduced cost, effecting a

saving in time of over five years. Great as is the magnitude of the Sutro tunnel undertaking, there are several others eclipsing it in extent and cost. In the Hartz Mountains a tunnel was constructed 14 miles long; and in Saxony a tunnel of 15 miles is in course of construction, to drain the Frieberg mines. This has already taken several years, and will require forty years more to complete.

A method of transporting timber to the saw-mills of the Carson River valley is sufficiently curious and ingenious to deserve mention. A V-shaped flume is constructed 5 miles in length; the material is 2-inch plank, depth 2 feet, fall 1 in 33, carrying a rapidly flowing stream of water. Heavy cordwood is thrown in, and transported the whole distance of 5 miles in eighteen minutes. At the end of the flume is an iron grating, having the reverse shape af the flume. The water escapes through this grating, and the wood by its own impetus shoots upwards, along the incline, and is delivered over the side.

Treatment of the Metals.

In nearly all the mills of the States some apparatus is used as an adjunct to the stamper battery—amalgamating pans, arrastra, Beath's grinder, centrifugal grinder, Ryerson's pulveriser, superheated steam apparatus, shaking tables, shaking pans, Chilian mills, cast-iron barrels, Ambler's concentrators, Varney's, Knox's, or Wheeler's pans, or two or more of the above.

On the adaptation of the treatment to suit the character of the rock depends the skill and success of the millman; in rock containing fine gold the reduction must be carried to a point according to its fineness, sometimes to an impalpable powder. I have already adverted to the fact of gold often occurring in large quantities in such a fine state of division as to be invisible (even with the aid of a magnifier). If the gold is coarse it is better not to use a fine screen, for reasons which will presently be shown. This is a subject deserving very careful attention. In this country, until lately, the quartz was nearly all stamped with uniform fineness, and at a fixed price per ton, instead of the price being regulated entirely by the fineness of the mesh. The stamping of quartz to the necessary fineness often absorbs double or treble the power and time occupied in ordinary crushing, the latter frequently leaving more gold in the tailings than is extracted. In the early days of California, it was not an uncommon thing to send to the mill ore worth £100 per ton, and to get from it only £14 to £16, the loss being accepted as inevitable. Whether the same sort of thing occurs here we can only say we are not sure about it, but it is certain that many large parcels of tailings in this country have been ascertained to contain more gold than the stone has yielded. From personal observation I can say that there is plenty

of quartz in this country containing ounces of gold, and only yielding pennyweights to the ordinary battery; and this same stone, if subjected to sufficient trituration, would yield up all, or nearly all, its treasure. The ingenious apparatus of Messrs. Lawson & Co. of Canterbury I look upon as eminently adapted for the treatment of some kinds of gold-bearing stone. But it is equally a mistake to use too fine a mesh for quartz containing only coarse gold, there being an unnecessary loss of power and time, without any corresponding gain. There is in fact no royal road by which the tyro may attain perfection of work,—every investigation points to the necessity of continuous and close watching, and the exercise of sound judgment, to meet changes as they occur, to foresee and avert loss, to detect it as soon as it occurs, and devise means of preventing its extension. In the stamper battery used in California there is very little to note; the stamps range in weight from 450 up to 1,500 lbs.; the fall is 8 to 14 inches; speed, 32 to 80 blows per minute; consumption of wood for every 10 tons of ore crushed, from less than one cord up to five cords; loss of mercury, never less than 7 lbs. for every 1,000 tons crushed, and sometimes as much as 100 lbs. for the same quantity; cost of extraction, 8s. to £6 6s. per ton; value of gold, 25s. to £20 per ton of ore crushed—taken from one year's average in each case; cost of stamping, from 2s. to 16s. per ton. In one mine the whole cost of treatment was covered by 2s. 6d. per ton. In the stamping of auriferous quartz it is not an unusual thing to reckon that two-thirds to three-fourths of the gold contents will be saved in the battery. The calculation is made on the total quantity saved, and certainly in the majority of cases no estimate is made of the gold lost in the tailings. The amalgamating copper plates in this country are often only 10 or 15 feet long, and frequently less; and some care is devoted to keeping them pretty clean, that they may work well. In California they are often 100 feet long, and are rarely cleaned, as they act much better when covered with gold. These plates catch gold more or less all the way; and although we have no actual means of proving what quantity of gold is lost after passing the short plates used in this country, we may reasonably conclude that some is lost which ought to be saved.*

The quantity of mercury used has to be regulated as nearly as possible by the quantity of gold it is expected to act upon; as a rule, 2½ to 3ozs. mercury should be used for every ounce of gold supposed to be in the stone, but the appearance of the amalgam is the best guide to an experienced eye. If too large a quantity used, amalgam will be lost; if not enough, it presents a rusty

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* In New Zealand there are several reefs where the tailings are worked to a great profit, and many which without the reworking of the tailings would leave a loss instead of a profit. The tailings from one mine alone were sold for £20,000, and it is alleged that the purchasers profited largely by the transaction.

appearance, and gold is being lost without amalgamation. The tendency in this country appears to be to use too much mercury.*

Loss of Gold.

In the year 1867 it was computed that the general loss in the treatment of gold quartz averaged from 20 to 42 per cent. through the State, but the subsequent introduction of improved pans for the treatment of tailings is supposed to have reduced the actual loss in some cases as low as 5 per cent. on the fire assay, when no sulphurets are present.

Chlorination.—The Californians concentrate and roast their pyrites by the usual methods, and appear to look with great favour upon the process of chlorination as a method of extracting the fine gold therefrom. The Commissioners speak of its success with confidence, and in my opinion without sufficient reservation. There certainly are conditions under which the process can be used with great advantage, but I believe they are exceptional. Those under which it appears to be not applicable—and which appear not to have been noticed by the Commissioners—are well known to metallurgists, and are as follow:—

When the pyrites are imperfectly roasted.

When any silver is present, as it becomes chloridized, coats the gold, and prevents it being attacked.

When any antimony or arsenic are present, and antimony gets converted into chloride and precipitates the gold.

When, through careless or imperfect roasting, sulphates are formed; as when metallic iron is present, as in either of these cases the gold would be precipitated.

When lime or carbonate of lime is present, as they absorb the chlorine.

When the gas is imperfectly purified, and hydrochloric acid carried over, as it will react on some metals, producing sulphuretted hydrogen, which will precipitate the gold.

As a general rule the gold in pyrites is fine, but I have known large nuggets of gold enveloped in pyrites, and these would be liable to be lost unless the operation were protracted beyond the usual time allotted to the process. Some years since, Mr. H. A. Thompson condemned chlorination as a commercially practicable process, in the columns of the *Sydney Mail;* I then defended it, but subsequent closer study of the question has developed difficulties, affording me the gratification of recognising Mr. Thompson's superior acquaintance with the subject. Whatever may be the character of the pyrites in California or the skill of the millmen, I think that in New South Wales a very small per-

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* It is a common practice in New South Wales to add every hour two spoonfuls or a tablespoonful of mercury, quite regardless of the condition of the amalgam.

centage of the men employed at reduction works would be competent to cope with the chemical complications which would be likely to bar their way to success in the employment of this process.

The yard, barrel, and pan processes for the extraction of gold and silver from their ores have repeatedly been made the subject of comparative experiment, and the following published result of some trials, in the Ophir Mine affords valuable and interesting information:—The yard process cost £6 per ton, and lost 20 per cent. of the metal; the barrel process cost £5 14s. per ton, and lost 15 to 20 per cent. of the metal; the pan process cost £3 per ton, and lost 35 to 40 per cent. of the metal. But this series of experiments did not reveal the whole truth; it was found that the loss by the barrel process was principally gold, and that by the pan principally silver, and the bullion from the pan was found to be worth just twice as much as that from the barrel process.

The Stetefeldt Furnace.—This is the only desulphurizing furnace which appears to claim notice in this paper. The one used at Reno, near Virginia, for desulphurizing and chloridizing the ore, consists of a shaft 20 feet high, by 3 or 4 feet square. At its base there are two fire-places, in opposite sides, with short flues leading into the stacks. The ore having been mixed with 3 to 6 per cent. of salt is crushed under stamps and passed through No. 40 screens. This finely pulverized ore is fed in a continuous stream by machinery from the top of the shaft. Just below the top of the shaft is a flue for the escape of the gases, leading into dust chambers, where any portion of the fine material carried up by the draught may deposit. The main shaft at the end of the dust chambers is 40 feet high. As the fine ore descends, mixed with salt, against the current of hot air ascending in the shaft, it becomes chloridized, giving off sulphurous and sulphuric acid; every atom of the ore being exposed to oxidizing and chloridizing influences. The furnace is said to perform its work with less cost for fuel, labour, and salt, than the ordinary reverberatory—one furnace treating 20 tons in a day, with the labour of eight men, which would require ten reverberatory furnaces and thirty-six men. The fuel used is two cords of wood a day, while the ten reverberatories would require five times the quantity, and the saving in salt is one-half. The bullion produced is larger and richer, and the cost of treatment only about 26s. per ton.

The loss on the Colorado ores has been pretty well ascertained: it is about 30 per cent. Of the quantity saved, 55 per cent. is obtained in the battery and appliances, and 15 per cent. by concentration and treatment of tailings.

Statistics.

The gold yield of California in 1853 exceeded eleven millions sterling. The gross yield from quartz mines is increasing slowly.

The capital invested in mines and mining is returning about 20 per cent. The average earnings per miner is at least 12s. per day on those mines which are opened. In some of the well known mines, the yield averages all the year round £4 per day for every hand employed.

In the mills of Virginia city alone they use no less than 923 pans of various makes, including the Knox, Wheeler, Hepburn, Varney, Wakelee, and Plain, and 400 settlers, agitators, grinders, barrels, tubs, and concentrators.

Fine gold—In the year 1860 the yield of gold was found to be in the Pine-tree district only 40 per cent. of the actual contents, owing to its being so fine as to be invisible to the naked eye. In the Mariposa district, for the same reason, the gold quartz which yields £10 to £12 10s. per ton used only to give 40s. to 60s. In the Pine-tree the whole cost of treatment only averages 24s. per ton.

Reduction works.—In the State of Nevada there are no less than 170; and their cost is put down at two millions sterling.*

Aqueducts.—One is now being constructed to convey the west branch of the Carson River 30 miles to the Empire City; another, known as the Humboldt Ditch, will be no less than 60 miles in length. Both of these are built to convey water to the mines.

Run of gold in quartz reefs.—Careful and systematic observation has demonstrated that they are rarely worked to a profit for more than 2 consecutive miles, and that pay rock rarely extends for more than 1,000 feet along a vein. A large mineral vein, however, is often traceable for 30 or 40 miles in a straight line, the rich portions being often far apart, and the intervals barren. This observation is the result of a very large experience, and no doubt applies to this as well as other countries; though I doubt if it has been made useful as a valuable item to the explorer to guide him in his researches.

The Comstock lode, believed to be the richest in the world, embraces an area of 3 miles in length and a third of a mile in width, equal to the area of a square mile. It produces annually two and a half millions sterling, while the loss on the ores represents not less than a third of the entire value; so that something like three-quarters of a million is allowed to go to waste every year. About 5,000 men are employed, and their average earning is equal to £500 per man per annum. The excavations in tunnels, shafts, &c., aggregate 67½ miles. The timber for mine use and firewood costs annually £200,000.

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* Clande informs us, after examination of some samples of Californian pyrites, that it contains gold, silver, copper, lead, cobalt, iron, arsenic, sulphur, and silica, in varying proportions. In three samples the gold has ranged from 8½ to 98½ ounces per ton, and the silver from 3 ozs. 18 dwts. to 11 ozs. 16 dwts. In the Grass Valley pyrites the bullion consists of 52 per cent. gold, and 48 per cent. silver—a proportion that would defy any attempt at extraction by chlorination.

Taxes on mining industry are very equitable in their character —half per cent. is paid on bullion; every miner earning over £200 a year pays £2 to the revenue.

In conclusion, the present paper has aimed at making known some of the facts connected with American mining, showing its progress in a remarkably short and recent period. The material possesses no claims to interest, beyond that connected with the information it may convey.

It appears from the researches of the United States Geological and Survey Departments that the locale of all the valuable minerals as at present known are well mapped out, while the geology in each case is indicated, and even the variations in the different classes of minerals indicated by changes in the lithological character of the ground. To the intelligent miner who avails himself of such information the value must be incalculable. The record and publication of all the improved processes introduced, as also the analysis and exposition of work performed, showing under what condition it has been attended with success, or otherwise, are no less so. Surely the adoption of a similar course—in any country possessing a sufficient population to justify the expenditure, and looking to its minerals as a source of national wealth—would be desirable. And in cases where the population is sparse, I can scarcely imagine any procedure more likely to attract immigration. Here we have no such advantages; and any prospection having for its object such discoveries must be made by private enterprise and at private expense, while there are no means of recording and mapping the results for general use. Very little Government aid and encouragement have stimulated the enterprising Americans as individuals to risk much and achieve more, and we may reasonably hope that the same results would be obtained in this country.

STANNIFEROUS DEPOSITS OF TASMANIA.

By S. H. Wintle, Esq., Hobart Town.

[*Communicated by the Rev. W. B. Clarke, Vice-President. Read 7 July,* 1875.]

1. Mount Bischoff.

Although much has appeared through the channels of the public Press respecting this remarkably rich tin ore bearing region, nothing that I am aware of has emanated from a reliable geological source as giving a detailed description of the structure of the mountain and the occurrence of the ore as a contribution to the Proceedings of the Royal Society of New South Wales. Under these circumstances I am induced to offer the following remarks, which are in accordance with the evidence presented by specimens of rock and ore collected during a residence of several months, in the hope that they may prove acceptable to the Society.

Mount Bischoff is situated about midway between the north-west coast and the west coast of Tasmania, with Bass's Straits on the one hand and the Pacific Ocean on the other. Were a line drawn from Emu Bay to about midway between Macquarie Harbour and the mouth of the Pieman River, it would bisect Mount Bischoff, and thus form a base line of a nearly equilateral triangle with Cape Grim. From Emu Bay—the nearest place of shipping—the Mount is distant about fifty miles by the road, which passes through a densely-timbered country, consisting chiefly of large native myrtle, pine, and sassafras trees, with a thick undergrowth of tree-ferns and various smaller species of the same, and through which at intervals, especially in the gullies, almost impenetrable belts of the " horizontal " of the early surveyors (the *Anadopetulam biglandulosum* of the botanist) obtain. Here and there this dense vegetation is relieved by patches of more open gum-tree country. [A very similar description was given by Mr. Gould. W. B. C.]

Along the north-west coast, for upwards of a distance of seventy miles, the older palæozoic rocks are exposed at intervals by the action of the waters of Bass's Straits. These consist of lower silurian and still older cambrian transition strata, all highly inclined,—indeed, in many instances, so much so as to be nearly vertical, while they are folded and contorted to a remarkable extent. These are chiefly clay slate, altered sandstone, limestone conglomerate, and quartzose rock, and which are much traversed

by veins and strings of quartz. In not a few instances the limestones are metalliferous, bearing veins of argentiferous galena, associated with pyrites of tin, iron, and bismuth. At a distance of less than one hundred yards inland these strata are covered up by basalt, which, as a rule, presents a beautifully prismatic structure, the columns being made up of pentahedral and hexahedral septæ with well-defined facets. On leaving the coast for the tin mines, the older palæozoic rocks are no more seen until Mount Bischoff is reached, being completely covered by the basalt, except in one instance where river action has cut through it. This being a dark augitic rock, often very ferruginous, vesicular, and occasionally amygdaloidal, its decomposition has furnished a rich chocolate-coloured soil, which will account for the dense vegetation of this part of the island.

Mount Bischoff has an altitude of 3,500 feet [Gould says 2,500 feet. W. B. C.] above the sea, and but little more than 1,000 feet above the surrounding basaltic table-land, the ascent being more or less gradual from the coast. It consists of erupted euritic porphyry, which forms a crescent-shaped ridge on the summit, the extremities of which ridge are not more than a quarter of a mile apart, the intervening space being a horseshoe depression or basin. It is here that the richest deposits of tin ore exist. This basin looks south, and presents a natural outlet to the surrounding table-land, while the northern and western slopes are exceedingly steep, presenting a mean angle of descent of 35°. The porphyry is the chief matrix of the tin ore. It has burst through the transition strata which repose on the slopes of the mountain, displacing, contorting, and folding them in a most fantastic fashion. These strata chiefly consist of clayslate, sandstone, and quartzose rock; the former being frequently highly charged with sulphides of iron and tin. The tin ore occurs as a binoxide, and traverses the porphyry in veins and lodes; the breaking up of which by subsequent eruptive forces scattered the tin ore on the slopes of the mountain in the form of talus. The transporting and arranging power of water as a cosmical agent seems to have played no part whatever in these stanniferous deposits; inasmuch as the particles and nuggets of the ore afford no evidence of having been subjected to attrition, but, on the contrary, display sharp, irregular edges. The disruptive force which shattered the lodes was probably the same as that which affected the vast basaltic flow of the surrounding country. The ore is not generally distributed over the sides of the mountain, but exists in local patches of limited extent in the majority of instances. In earnest of this I may mention that on Messrs. Walker and Beecraft's section 240 tons of ore were taken out of a chain square of wash-dirt, while at a distance of about 20 yards on either side of the cutting barely a trace of the ore could be obtained. Some of the masses or nuggets of ore taken out of

the wash-dirt on this claim, or from between loose fallen masses of porphyry, weighed as much as 6 cwt. Not a few of these masses were almost entirely free from the matrix. It seems somewhat remarkable that where there are such strong evidences of the existence of lodes in the immediate neighbourhood of these tin ore deposits only one actually well-defined lode has been laid bare. This occurs on the Waratah Company's claim, which is bounded by Messrs. Walker and Beecraft's section on the west, and Messrs. Giblin and Wintle's section on the north. When it is remembered, however, that, although nearly two years have elapsed since mining operations were commenced, and that during that time not half an acre of washdirt has been collectively removed, this apparent anomaly is somewhat modified. Evidences of shattered walls of tin lodes are daily brought to light. It would seem that in the case of Messrs. Walker and Beecraft's rich claim the removal of drifts cannot be carried on many yards further in the direction of the summit of the ridge of the mountain before the source of the rich washdirt is reached. In a hole sunk to a depth of 20 feet, and about 30 yards in advance of the face of the excavation, large masses of tin ore lie so thickly embedded in a cement-like matrix that recourse has been had to the mall and wedge to remove them.

The eminent geologist and mineralogist of Victoria, Mr. Ulrich, joins issue with me respecting the existence of actual lodes of tin ore at Mount Bischoff. I had the good fortune to be at the mines when he visited them. His opinion then, which he has since published, was that the tin ore occurred in the porphyry as "bunches." Since then the lode on the Waratah Company's claim has been discovered, and most of the other evidences of their existence in other parts brought to light. In the associated sedimentary strata, numerous crevices and joints are found filled with casserterite, but these are generally too small to have any value. The depth of the stanniferous drift varies from one foot to thirty feet, the greatest depth being as a rule on the steepest slopes.

Although the euritic porphyry is the chief source of the ore, there are rich deposits consisting of tin and peroxide of iron, as is the case on the Mount Bischoff Company's ground, where a face has been opened up to a depth of thirty feet. This excavation is not more than eighty or ninety yards from the works on Messrs. Walker and Beecraft's claim, and presents entirely different characteristic features. No large masses of white porphyry are seen here, among which the tin ore is disseminated in coarse particles and large nuggets, but, on the contrary, fine-grained black tin is found dispersed through a drift composed of concretionary fragments of iron ore and coarse sand. Ascending the slope of the basin from the face of their works in going to the top of the mount, the tin, iron, and sand assume a cemented condition, and finally, at the summit, appear in cliff-like masses of a conglomerate

of tin, iron, and silica, which is sufficiently hard to require blasting. This is called the north lode, and it can be traced for fully half-a-mile on the ridge of the mount. I regard this as nothing more nor less than a highly ferruginous and stanniferous porphyry, the disruption and subsequent decomposition of which has formed the drift deposit on the side of the basin now being worked. So rich in tin stone is this formation that blocks several hundredweight of nearly pure binoxide of tin are broken off. The porphyry occurs in three different conditions at Mount Bischoff: first, as highly ferruginous, as at the Company's ground; secondly, as a very felspathic rock, slightly coloured by the presence of oxide of iron, as seen at the adjoining claim of Messrs. Walker and Beecraft, and other sections; and thirdly, as a light-green-coloured rock, which appearance is due to the presence of olivine. In this latter condition, let me observe, I have found it hitherto poor as a matrix of tin ore. Small grains of native copper have been found associated with the ferruginous tin ore; while on an adjoining section belonging to the Company rich argentiferous galena obtains. Nothing up to the present time has been done to develop the latter ore. Lodes of sulphides of antimony and zinc exist—the former having a gangue of carbonate of iron and fluor spar, the latter of fluor spar alone.

That Mount Bischoff has suffered much dislocation by eruptive forces is seen by an extensive line of fault running north and south, whereby the whole of the eastern side of the mountain has been depressed, thereby producing a line of vertical cliffs in some parts little less than 100 feet in height, and which afford a fine example of how the eruptive and intrusive porphyry has contorted and transmuted the older sedimentary strata. On the top of this line of cliffs the older palæozoic slates repose at intervals where the igneous rock has not burst through, while at the base they are again seen having the same strike, which is north 10° east.

Up to the present time, I may observe, sluicing operations have been carried on by dam water, which, after passing through the sluice-boxes, returns to the reservoir, to be again pumped up. As a consequence, the water is always thick, and much of the fine tin ore is carried away in the tailings. At least 40 per cent. thus escapes. Now, however, that a tramway one mile and a-half long is nearly completed to the Waratah River, which encircles half of the base of the mountain, and where there is a never-failing supply of clear water, and also falls 154 feet high, all the rich tailings will be dressed and crushing-mills be set in operation by the water power.

The traveller, in ascending Mount Bischoff, passes at a single step from the great basaltic flow occupying the surrounding country to the stanniferous porphyry, the point of contact being most clearly defined.

Before closing my remarks on this great source of stanniferous wealth, a few words descriptive of the climate and the vegetation of the region may not be considered altogether out of place. The climate of Mount Bischoff is simply execrable. It is a proverb that it rains at Mount Bischoff when it rains nowhere else. As a rule it rains nine months out of twelve. The terribly dense nature of the surrounding myrtle forests, doubtless, has much to do with this meteorological condition of things. The result is that all vegetation is thickly draped with moss, also the boulders scattered over the surface of the ground. Club mosses abound, the growth and decay of which have furnished a covering of peat seldom less than 1 foot, but more often 4 and 5 feet thick. This, and the dense scrub and larger timber constitute the stripping of the miner, for immediately beneath is the washdirt.

Nature, perhaps, never threw greater difficulties in the path of the pioneer of a country's mineral resources than those met with at this inhospitable region. The great barrier which confronts him on every side is the growth before mentioned—the "horizontal." It consists of trees whose stems and branches have a circumference, as a rule, varying from 1 foot to 3 and 4 feet, and which have a peculiarity of twisting, folding, and interlacing themselves to such an extent that a vast arborean reticulation is presented, often to a height of 25 feet, and through which an object is seldom visible at a distance of ten yards. At short distances through this network tall myrtle and pine trees ascend, whose branches, often meeting overhead, produce a Cimmerian gloom, through which the sunlight never penetrates. The rank odour of decaying vegetation is often almost overpowering. Everything is covered with moss and fungi. Hence the moisture is sufficient to render the country a fit habitation for a species of land lobster, whose circular mud-built walls and burrows are found everywhere. These opposing obstacles to the prospector are gradually vanishing. Tracks are being cut in all directions, and ere long in the silence and solitude of the primal forest, with its impenetrable barriers of "horizontal" will be heard the sound of the miner's pick, the boom of the blast, and snorting of the engine—those forerunners of advancing civilization.

2. Mount Ramsay.

At a distance of about ten miles from Mount Bischoff, Mount Ramsay rears its bold front to an altitude of over 4,000 feet. This mountain has no place on the map of the island, it having been recently named by the late Government Geologist of Tasmania, Mr. Gould, in honor of the President of the Geological Society of London. It would seem that the early surveyors had not penetrated so far inland in a southerly direction, probably

owing to the difficult and dangerous nature of the country lying between it and Mount Bischoff. Mr. Gould was the first geologist who visited it, and from what he said of the character of the country my services were secured to conduct a geological and general prospecting expedition in the neighbourhood.

Mount Ramsay is essentially composed of a coarse tourmaline granite occasionally passing into a fine-grained rock. This granite rises in three bold lofty peaks. Unlike Mount Bischoff, the older palæozoic strata are seen only around the base. The creeks and gullies furnish very superior ruby tin ore, associated with considerable quantities of zircon sand and tourmaline ; but the tin occurs in much less quantity than at Mount Bischoff, the best of my prospects seldom reaching an ounce to the tin dish. Since I was there, however, more than twelve months ago, very promising indications of lodes have been found, consisting of rounded nuggets of nearly pure binoxide of tin, varying from the size of a marble to a hen's egg. In accordance with my advice, these have been followed up till portions of lodes have been obtained, showing very little sign of abrasion. Mount Ramsay, however, is better known for the remarkably rich and large lode of bismuth. This is said to be between 30 and 40 feet in width, while it has been traced for a considerable distance. This valuable discovery was made after I left the locality, while a party was prospecting for tin, and which latter metal, in a native state, they at first took it to be. As is often the case, the bismuth is associated with considerable quantities of wolfram. Very recently some highly promising samples of copper ore have been found there, both in the form of carbonate and sulphide. This locality bids fair to be a powerful rival in its metalliferous deposits to its neighbour, Mount Bischoff. A pack-horse track is now being made from the open country to bring away the bismuth.

From the summit of Mount Ramsay a large extent of mountainous country is seen stretching away in the direction of Macquarie Harbour. Mountains, with broken and rugged outlines, presenting vertical precipices many hundreds of feet in height, as though they had been rent in twain, are visible, with the waters of the Pacific Ocean dimly observable in the distance. As seen from this point, the panorama is truly grand, and might be compared, to use a metaphorical simile, to a tempest-troubled sea, suddenly frozen. And yet this at the present time is a *terra incognita* to the geologist and prospector, but offers a fine field to some of those "mute inglorious Raleighs," whose courage and noble self-sacrifice have done so much to benefit their fellow-man.

Before taking my leave of this north-west part of Tasmania, I must briefly refer to two other localities where stanniferous deposits have been found. One is at Wombat Hill, about midway between Mount Bischoff and Mount Ramsay—the other at Mount House-

top, 20 miles from the north-west coast, in an easterly direction. Both of these localities are granitic, and furnish ruby tin, but in quantities that leave it doubtful whether they will pay to work. At Wombat Hill the tin ore is extremely fine, and is associated with considerable quantities of chromate of iron and titaniferous iron sand; while at Mount Housetop, not only the two latter minerals largely exist, but also pleonaste.

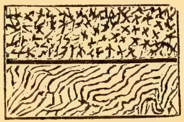
3. George's Bay, East Coast.

In the month of October last I visited the east coast of Tasmania in search of tin ore deposits, being led thither by a knowledge of the fact that a large extent of granite-bearing country extended in a belt, with but few interruptions, for a distance little short of 100 miles on this side of the island. From Schouten Island, where a very coarse granite, containing very large crystals of felspar, rises in bold lofty hills, I found this rock to occupy nearly the whole of the coast line. Here and there depressions, a short distance inland, are occupied by carboniferous deposits, as for instance, at Bischeno and on Schouten Island itself. Upon reaching George Bay I found the granite to assume a rather finer grained character, and very much less micaceous, the gravel formed by the decomposition of this rock furnishing small grained ruby tin ore in small quantities wherever I tried it near the sea-coast. At a distance of 10 miles inland, in a north-westerly direction from the bay, I found the granite covered up by altered palæozoic rock rising in hills of considerable altitude, and these in turn become covered with greenstone; the intervening country being occupied by low undulating hills of granite, thickly covered with gravel and pebbles of decomposed granite, the whole of which is stanniferous; the ore almost invariably being associated with sapphires and zircons, which, however, are too small to have any mercantile value. At the head of a rivulet the source of a fine stream, known as the Golden Fleece, I discovered tin ore in highly payable quantity, extending over a considerable area. This locality forms the scene of operations of the Ruby Tin Mining Company, and is only 5 miles from the place of shipment at George's Bay. The country is openly timbered with peppermint trees, and is frequently marshy. The depth of wash-dirt ranges from 1 foot to 8 feet, the maximum being for the most part on the hill tops, which are frequently small plateaus. This stanniferous district extends in a south-easterly direction as far as Falmouth and the Mount Nicholas Range. More recent discoveries show that tin-ore-bearing country obtains at a greater distance in the north-westerly direction, as for instance, at Boobyalla, Mount Cameron, Mount Horror, and in the Ringarooma district or Gould's new country. Scarcely a day passes without tidings of fresh tin ore discoveries being made in this part of the island.

From what I have stated it will be seen that Tasmania gives great promise of soon becoming an important tin-producing colony, and is already attracting the attention of Victorian capitalists.

N.B.—A "Note upon a Recent Discovery of Tin Ore in Tasmania," by Charles Gould, Esq., B.A., F.G.S., was read before the Geological Society of London, on June 24, 1874, and was published in the "Quarterly Journal" of that Society, vol. xxxi. p. 109, (issued February 1, 1875). Mr. Gould's remarks are chiefly on Mount Bischoff. W. B. C.

DIAGRAM of VERTICAL SECTION of Line of Fault on Messrs. Giblin and Wintle's section Mount Bischoff.



Scale ½ inch to a chain.

PERMANENT WATER SUPPLY TO SYDNEY BY GRAVITATION.

BY MR. JAMES MANNING.

[*Read before the Royal Society, 4th August*, 1875.]

ON the 9th December last I had the pleasure of addressing my first paper on the above subject to this Society; and now I approach the matter once more, in order to give the results of my further experiences, which have been matured by more elaborate surveys of the locality from which I propose to supply this city with an abundance of the purest water by direct gravitation.

Before entering into the details of the subsequent surveys, I desire (in the first instance) to preface this paper by saying once more that, in advocating my own water-supply scheme, I have only had the good of all in view, and that I am actuated by no invidious motives towards all the other projects which have been before the public, each of which has its own special merits; but I trust I may be pardoned, and not be thought to be presumptuous, by saying at the same time that every one of such schemes seems to me also to have its own special objections.

It was not until 1873 and when I made my surveys in quest of a good railway route into Illawarra from Sydney, that I became alive to the great advantages presented by the remarkable north-westerly dip of our immense coal basin from beyond Kiama to Port Jackson; that I saw the double chance of securing a water supply for Sydney by direct gravitation, as well as to secure an almost level railway line into Illawarra and to the southern coal fields; the dips of this extraordinary formation being no less than 40 feet to the mile, from south to north, for a distance of some 60 miles along the coast, and 60 feet to the mile to the westward, or inland.

It is not in my province to criticise the other and various plans for supplying the city with water, unless it be perhaps to point out objections to one particular scheme which does not seem to have been alluded to by others. Public attention has lately been brought to bear upon the merits of our present water supply, but as no one seems to have given expression to the great objections to

a supply from the Botany side, in the same manner that they have struck me, I desire to say, before I propound my own scheme any further, that I see serious objections to Mr. Bell's (the City Engineer) proposal, beyond the one great objection of the water supply from that side becoming more or less polluted through the proximity of the city. I see in this plan two other strong objections, the least of which is that it is only a pumping scheme at best, and therefore subject to dangerous casualties. But there is another and infinitely more important objection to any Botany Waterworks in future; and this by reason that as it can neither be looked upon as Quixotic or chimerical to imagine the future of Sydney as a great manufacturing city, and that if it is to become the Birmingham and Manchester of the Southern Hemisphere, so will the area and the waters about Botany be required for the purposes of manufacture.

This locality would be remarkably advantageous for such purposes, for the following reasons:—

1st. That in the probable event of coal being brought by railway from the south, it will be readily accessible for a cheap supply of coal.

2ndly. That there will be a sufficient abundance of water there for manufactories.

3rdly. That it presents admirable advantages for carrying off all waste water and impurities into a sea basin (Botany Bay) which would be remote from the greater centre of the city population.

These considerations point to the probability of the whole of the Lachlan Swamp and land adjacent to the watercourses from Paddington to the Bay becoming a great manufacturing suburb, and that it will be advisable therefore to look to more remote, and, I dare say, purer sources for the supply of water for human consumption in the metropolis. Independently of this prospect of this land being required for manufactures, it appears to be sufficiently obvious that it cannot be advisable to cramp the extension of a growing city by these reservations of, or shutting up of three or four thousand acres on its outskirts, a reservation which it is avowed would be absolutely necessary, in order to prevent pollution of those waters with which Mr. Bell proposes to supply the city. And here too we should bear in mind, that such reservation and locking up of the most valuable manufacturing and building sites would involve a loss that would alone probably represent the total expenses of a direct gravitation water supply scheme in enclosed mains from the Illawarra Mountains.

With this preface to my paper, I will hope that the peculiar and very important social interests involved in this matter will be quite sufficient apology for your not having a paper read

before you that should savour more of abstract science, as befits these meetings perhaps more than such a subject as that of water supply can well give rise to; at the same time I trust that we may claim its adaptation to our Society, by reason of its being a subject for so called "social science," which term seems to me to imply the application of the valuable principles of abstract science to the practical benefits of mankind.

Reverting to the former work of my survey in last October, I may say that the sudden illness of my surveying assistant, as well as of myself, obliged me to disband my party when my survey was incomplete, and that I was compelled afterwards to finish the remainder of the work hurriedly by means of a prismatic compass and of an aneroid only, in lieu of the proper instruments which I had returned to Sydney. But not being satisfied with the supposed elevations taken, I resolved, later on, to renew my survey, and to take complete and true elevations which should all be connected with the sea level at high-water spring tides. The second survey, I am happy to say, was most satisfactory, and has led to very improved results, although we found that the former aneroid observations had betrayed me into serious mistakes as to the extent of area available for water reservoirs. Happily, however, these aneroid deceptions told both ways, because my corrected survey showed 6 feet more depth in my intended lake for some 60 chains up the main valley fronting the proposed dam. My further work also disclosed the uselessness of trying to impound so large a body of water as 2,000 acres thereabouts, as before named by me, partly because the true levels proved that such a large impoundage would be impossible; and because I could see that such vast bodies of stagnant water, if obtainable, would be undesirable, and would only lead to excessive waste by evaporation, and to vegetable growth over the extended outer and shallower surfaces.

I saw also that by making subsidiary dams up each of the four main and permanently-running creeks, I could multiply the storage of water very considerably, but to no good end, inasmuch as I found that by confining the expense of dam-making mainly to the one great storage dam in the mountain valley of the Loddon, which should be suitably built to be capable of being added to when required, we could impound about 2,000 million gallons of water by raising the one dam across a very narrow gorge of sandstone rocky hills 50 feet only; and that as that amount of impounded water would alone represent quite 400 days' supply for all Sydney, at the rate of its present extreme delivery of 5,000,000 gallons per day by the Botany pumps, so I thought that a proposal for any further expense for impounding more water, unless by small storm-water embankments, would imply a total waste of money until the extension of the city should make it necessary

to increase the supply by raising the one large dam 20 feet higher, and by extending the south aqueduct to lead more waters to the tunnel mouth.

Before entering into the details of my survey for the large impoundage of waters at this place, I desire to say that this proposed large storage would not be the source at all of the ordinary supply for Sydney, but would be only supplementary by way of a standby in times of drought. I wish it, therefore, in the outset to be borne in mind that, by my scheme I propose, in ordinary seasons, to supply all wants of the city by the regular flow of the waters planned to be conducted through the Loddon tunnel, which would have its incessant supplies given to it by all the head sources of the Cataract River south of the tunnel mouth; by the overflow waters of the proposed Loddon Lake, supplied by four permanently running creeks, to be discharged into the tunnel inlet just below the great dam; by the regular flow of the head sources of George's River, known as Madden's Creek, which would be conducted into the Loddon tunnel by a shaft of 60 or 70 feet; and by the overflow of the proposed smaller dam, on one of the heads of the Woronora River, into the open canal beyond the exit of the tunnel waters. All these waters to be led on to the high gravitation iron mains, which would be situated at 1,062 feet above the sea, and about 28 miles from Sydney. By this delivery of waters, any excess of supply from such aqueducts, tunnel, and canal, could pass on down the falls of the Port Hacking River, there to subsidize, if required, an additional low-level scheme, which might alone give a sufficient daily supply in all seasons for Sydney, by the adoption of my proposals as shown in my last paper read before this Society, and as shown by my map now lithographed and laid before you on this occasion.

Further, I would desire to say that, by my plan of making the aqueduct high enough up to cause the waters to flow into the proposed tunnel-mouth at 1,120 feet over the sea, we can intercept nearly all the Cataract waters from going down their present natural course; and that in dry seasons we should, in such cases, see that the daily delivery through the tunnel alone would probably be greater than the gauging of the Cataract River at its lowest levels would show, inasmuch as in such seasons the head springs continue to flow freely long after the waters have ceased to flow down the main Cataract gorges into the Nepean River; and my late surveys on the west slopes of the Bulli, Wonona, and Mount Kiera mountains all go to show that the great supply sources come from the swamps, which are mainly at an elevation of 1,200 feet, or above the level of my proposed aqueduct or channel from the south.

I wish to repeat here the remarks which I made in my former paper on this subject of water supply,—that my single proposed

tunnel of 3 miles and 35 chains would be all through compact sandstone, and would be only one-third of the length of tunnelling planned for the Nepean water scheme along its course of 63 miles.

I would also add at this part of my paper that the watershed that would be commanded by my scheme would be of a nature that it would be impossible to compute the area of until a most expensive survey was continued to the south from the proposed Loddon dam. But this much may be asserted without hesitation,—that the watershed available for the whole project would be far in excess of requirements, as all the countries to the south of the proposed Loddon dam and tunnel above the levels of 1,121 feet, and up to 1,300 feet, say for a course of quite thirty miles (allowing 6 feet fall to each mile), would command an enormous watershed from a country which rises 40 feet to the mile all the way to the Bong Bong Mountain, near Shoalhaven. Practically the watershed that my scheme would command would absorb nearly all the supply waters of the Nepean water-scheme, besides absorbing the head sources of the Georges River watershed; and without drawing upon the Port Hacking large supply waters at all, but which could be made use of by my plan if wanted.

Under my present project for the supply of Sydney, I desire to say that I am confident that an excessive quantity of water would be supplied for a much larger demand than Sydney now requires, without extending the south channel further than to be able by it to divert into its course all the upper sources of the Cataract River, the falls of which are bounded by the coast range on the east, and by the high level track or road which passes from Wollongong by Mount Kiera on towards Appin.

I also wish, by this Society, to place my remark on record that should Sydney, in times to come, so increase as to become one of the largest cities in the world, future generations need never fear a short delivery into the city, because it will be found that they could continue my proposed channel under the above-named Mount Kiera Road by a short tunnel of less than half a mile, and about 200 feet below that part of the Mount Kiera and Appin Road, where I made it 1,400 feet over the sea, and exactly where such tunnel would have to penetrate the ridge which divides the Cataract from the Cordeaux waters. This being done, the channel could continue for miles and miles on the western slopes of Mount Kembla, and on and on for perhaps 30 miles by its own necessary elevation of from 1,200 to 1,300 feet, along a country which rises constantly on an average of 40 to 41 feet to the mile south. Along such course there would not be any deflections towards the coast to interfere with the onward progress and success of a south to north aqueduct. Such channel, aided by storm dams here and there, might be made to lead an

entirely new river in a northerly direction to connect with my present proposed channel to be led on through the Loddon tunnel to the high gravitation mains, and thus insure to the future Sydney an unparallelled water supply by high gravitation.

I must now proceed to give an account of my survey made in the months of February and March last, and followed in May and June by subsequent aneroid observations taken in three separate trips to Illawarra. I began my second survey by measuring off the true levels, at the proposed dam, at elevations on both sides of the Loddon River of 50 feet. I then started the levels and the traversing from the eastern peg of the dam at its intended overflow over a ridge into another creek close at hand. We maintained that exact level all round the various valleys which debouche into the Loddon River, until after surveying round for seven miles and three-quarters, under six days' work, we had the gratification to find that our workings with the instruments had been so very correct that, on our approaching the western side of the dam, and when we thought that we were still some distance away from it, we found that our sights for the true levelling had been so correct that our last sight with the instrument cut the ground at only six inches above the western peg of our first 50-feet level for the dam itself from the corresponding point on the eastern side, from whence we started.

I mention this interesting fact as a proof of the correctness of the survey, and of the true taking of all our elevations everywhere, from the sea level up, and which reflects great credit upon my young assistant in the survey, Mr. Carl Weber, who worked the instrument and kept the field book.

My new map, which embraces all the late survey work done in February and March, as well as that of the first survey in October of last year, shows the proposed impounding of 366 acres of water by the intended "Lake Loddon," whilst the soundings of such contemplated deep water lake are shown sufficiently on the face of the map, in feet, to enable you to have some idea of the vastness of the supply for Sydney, which can be so readily and safely impounded there by the formation of one fine dam, with 50 feet elevation only, to be made in cement concrete, from broken roadstone, sand, and Portland cement and water, as proposed in my former paper.

The estimate of the contents of the lake is based on a calculation of the cube of the depths, and by taking $6\frac{1}{8}$ acres at 6 feet deep to represent ten million gallons of water, whilst by averaging the depths of the soundings (without cross sections being taken) we arrived at the estimate of 2,000 million gallons of storage waters, or nearly four times as much storage capacity as all the Lachlan Swamp and Botany dams put together would represent. It is difficult to convey to the mind of those who have not seen the

country how vast such a supply would be; but in order to try to convey a practical idea of the expanse and depth of such a lake, I beg to inform you that supposing the great steamships the "Whampoa" and "St. Osyth," when loaded, were to be floated there, those ships could make a cruise of two and a half miles from the dam and back, and would in that distance never have less than six feet of water under their keels; whilst such vessels as the "Emu" on the Parramatta River, could cruise for six miles around various arms of the lake forming bays of shallower depths.

On reference to the appendix of this paper, which exemplifies the construction and cost of another cement concrete dam erected lately in Victoria for Geelong water supply, it will be observed that it cost £17,306 12s. for conserving 141 million gallons of water, which brings the cost on each million of gallons of water storage equal to £122 15s. By the estimates of the storage capacity of the Loddon reservoir, roughly stated 2,000 million gallons, we could, *cæteris paribus*, afford to spend £245,500 on the Loddon concrete dam of same nature as the one at Stony Creek, distant twenty miles from Geelong; but as this is probably a larger sum by more than four times than would be required for the erection of the Loddon dam, sluices, and valve-house, it would give a fair result at such comparative cost of £61,375, and would place the cost of storage of each million gallons at the almost unprecedentedly low price of £30 13s. 9d., which indicates in a remarkable manner the superiority of the position for the Loddon dam.

Let us now consider the chances of so large a reservoir being filled by the adjacent watershed. During the period of one month that I was engaged in my last survey, we estimated that probably enough water passed down those various branches of the Loddon River to be nearly equal to fill the whole of the lake to its full depth of 50 feet at the dam. The floodmark at the narrow pass where I have marked off the proposed dam showed a perpendicular rise of 14 feet 2 inches and 8 chains wide by the last flood previous to the survey; and there is reason to believe that on Saturday, the 6th of March last, it must have exceeded 16 feet at such pass. I am, therefore, quite satisfied that the watershed of that high district, close to the sea, is quite ample for all our requirements.

It has been remarked by several, that probably the country would not present good retaining ground for large reservoirs. This is, however, quite a mistake; and in satisfaction of this important question, and of the adaptation of the country for such purposes, I desire to adduce evidences in favour of my assertion. First, then, the whole watershed is formed of the coal sandstone as I fully described in my first paper on this subject. The whole formation there is a bare sandstone rock, covered with sand, the debris of itself. Here and there the sands are peaty; but nearly everywhere the waters are to be seen oozing out of the sides of

the hills and on the flats, as if they were being given off from the coastside by reason of the north-westerly dip of the stratifications of the coal sandstone formation.

Secondly, the vegetation of this neighbourhood is very remarkable, and indicates the swampy holding ground of the whole watershed, from the highest tops of the hills right down to the lower flats. The whole country is nothing else than one vast swamp, with various hills capped with poor sandy soil and scrubby timber. I remarked with peculiar interest, and in proof of this water-gathering ground being like an immense sponge in all seasons, that nowhere could I see one single plant of the true grasses, although the whole country looked as green when I was there as if it had been covered with the dark foliage of the rich perennial ryegrass; but it is no such thing, as I convinced myself that not one single specimen of the true grasses existed anywhere there indigenously or at all.

The so-called grasses of that district belong to what German botanists designate by their significant nomenclature of the "Schein-grässer," or in English "make-believe grasses," which for the most part belong to the swamp plants of the three different families known as the *Cyparaceæ*, the *Restiaceæ*, and the *Junceæ*, each of which have their various and extensive sub-divisions, and abound over this watery country. The two first-named families seemed to abound the most, by the presence of varieties of the *Carex* tribe which in English are commonly called "sedges"; also there are large quantities of the *Schœnus*, which is one of the so-called knot-grasses, with its peculiar bunch of flowerlets and seed-vessels; besides a general prevalence of large masses of rushes, which belong to the *Junceæ* of the third family. Added to all this peculiar vegetation, the mosses and lichens abound sufficiently to help to form the peatiness that exists partially over the surface of this singular district.

The practical proof of the seeming grasses being "make-believe grasses" is this—that none of them have any knots in their stems, and their stems are not round. The seed-vessels of many of them very much resemble some of the true or genuine food grasses; but the true grasses may be determined by the fact that they possess knotty sub-divisions in their stems, which are round and are like the cereals—wheat, oats, and barley, which belong to the true *Gramineæ*. The monopoly of these peculiar swamp grasses over this water-gathering ground is, I consider, the greatest proof that can be brought forward of the retaining capacity of the ground.

Lastly, the animal life in that region bears similar testimony of the peculiarly swampy nature of that country. There seemed to be no life there but the kangaroo overground, and the crayfish everywhere underground in the swamps and in the waterholes.

The whole face of the country seems to have been completely rooted up by these crustaceæ; they burrow underground in the swamps in search of food, which they probably obtain from the bulbs of the "lily grasses" just named; they also abound in all the waterholes. The presence of these animals over this peculiar country may well be regarded as another evidence of the permanently swampy character of the land.

The prevalence of these crayfish or land lobsters should be taken by us as a warning against the risk of making dams within their region of mere earthworks and timber, for they might riddle the strongest structure in a very short time, and perhaps ruin the finest dams that could be thus made. In Victoria many dams have been destroyed by these crayfish, and in America they have the same experience, in support of which I will here quote from the "American Journal of Science and Art" the following applicable passage:—"The habits and instincts of certain crawfishes are very extraordinary; thus the astaci are migratory, and in their travels are capable of doing much damage to dams and embankments. On the little Genesee River they have, within a few years, compelled the owner of a dam to rebuild it. The former dam was built after the manner of dykes, *i.e.*, with upright posts supporting sleepers laid inclining up the stream; on these are laid planks, and the planks were covered with earth. The astacians proceeding up the stream would burrow under the planks, where they rested on the bottom of the stream, removing bushels of dirt and gravel in the course of a night. They travel over the dam in their migrations, often climbing posts two feet high to gain the pond above."

From these remarks, we have further good reason for constructing the proposed Loddon dam entirely of cement concrete as one monolith, in the same manner as was adopted by the engineer Herr Ritter, at Frieberg, in Switzerland, as described in my translation from the German of Delebar's paper on the great waterworks, for water supply and for extensive motive power, erected there by him so successfully within the last five years from the time of their commencement, and now in full industrial operation. Delebar's paper, with its copies of the Swiss diagrams of the Freiberg works, form an appendix to my first paper on Sydney water supply by gravitation.

This method of making cement concrete dams has been adopted by Mr. G. Gordon, the Hydraulic Engineer-in-Chief for Victoria, who originated works of this nature in India, before he was aware of the somewhat similar system adopted by the French engineers, Messrs. Graeff and Delocre, in their construction of the great Furens dam at St. Etienne. Mr. Gordon has erected a cement concrete dam at Stony Creek, near Geelong, and which

is perfectly tight and successful, as may be seen by my appendix to the present paper.

On reference to my map you will perceive that there is a high range that divides the Loddon waters, which run into the Cataract River and then into the Nepean, from the Madden's Creek waters, which run into George's River and Botany Bay. The highest point of the range on Madden's Plains is 1,331 feet over the sea, as proved by my survey. Prior to my late survey the elevations in that district had only been determined by barometrical measurements, and not with the proper instrument and staff. From the northern side of this dividing range which separates these two watersheds we can obtain further supplies for Sydney by my scheme, as you may perceive by looking at the map. You may there observe that instead of making large dams on the Madden Creek, as I had before advocated, I now propose to adopt only one small storm-water dam, capable of impounding only twenty-six half-acres of water at the surface, with the view of intercepting the upper waters after heavy rains, and of letting off such waters down the creek gradually by means of a sluice and valve, and so to conduct them by steady gravitation down the creek to the intake of the shaft at point E on the map, and which shaft would take these Madden Plains waters down into the Loddon tunnel, at a depth of about 70 feet, and then pass on with the other tunnel waters into the open canal and on to the intake of the wrought iron mains on the Bottle Forest Road, at an elevation of 1,062 feet over the sea.

Should one storm-water dam be insufficient to arrest all freshes as they come down this small watershed from Madden's Plains proper, another might be made a little above the first one which is marked on the map. By this arrangement, aided by the little embankment at letter N, we should probably always intercept the waters of Madden's Creek instead of letting any part of them pass over Rice's Falls, close by, on their way to George's River and Botany Bay. Here I may state that my map shows an elevation of this storm dam on Madden's Creek, and that under such sketch is the following note :—"It is to be understood that dams of this nature (with concrete cores only) would have to be made everywhere along and above the southern aqueduct, where the levels would admit of them. This arrangement would be with a view to obtaining exceptional supplies."

It is quite impossible, within the limits of a paper like this, to enter sufficiently into the various details of my scheme, so as to be clearly understood ; therefore it is that I have endeavoured to make my large map almost self-explanatory of the whole project, and in which I may hope to have succeeded, although at the risk of being thought to have overcrowded it with matter.

You will thus see that I have shown ways and means of supply-

ing Sydney permanently with an abundance of the purest water, even without passing on for more supply beyond the position of the main storage dam. But I am happy to inform this Society that my last survey quite confirmed everything that I had before stated as to the practicability of availing ourselves of the favourable dip of the country for supplying Sydney still more abundantly. With reference to the prospective plan of supplying future requirements by securing the waters from the coast range further south, I was at first apprehensive that the indentation of the south coast range at Westmacott's Pass, behind Bulli, might possibly interfere with the requisite levels. The survey, however, dispelled this anxiety, and proved a remarkable fact, namely, that the lowest point of this gap in the coast range would be 10 feet below the surface of the Loddon Lake when full, and that, therefore, it would be impossible to run the southern waters by a channel into the lake itself, which would be distant from the gap about one mile. Most happily, however, we found that there were 40 feet 2 inches to spare on the relative elevations of such depression at the gap of the range, and of the position of my proposed tunnel-mouth, situated just below the intended great dam; for although we could not flow such waters into the storage lake at all, yet 5 feet alone of fall from Westmacott's Pass to the tunnel-mouth below the dam would have insured our being able to supply Sydney by gravitation wholly with the Cataract River waters, when supplemented by the other waters just named, *without having to draw upon the Loddon Lake at all unless under very severe droughty seasons.*

This was the most interesting part of my work and discovery. My levels were taken from high-water mark at spring-tides by Bulli. The lowest depression in Westmacott's Pass, or gap, proved to be 1,161·11 feet over the sea, whilst my proposed tunnel-mouth was 1,120·91 feet, which showed a balance in favour of the success of my work to the tunnel of 40·20 feet, and a total fall from the gap of just 99 feet to the intake of the wrought-iron mains, which would be north, and 8¼ miles from Westmacott's Pass. I trust, therefore, that I may be pardoned for saying here how rejoiced I felt when I found that the instruments proved that we had thus 40 feet to spare for this development; because I knew that, this Charybdis being passed, I had no Scylla to fear, and that all the southern waters of the upper elevations for miles and miles along the coast range south were or could be completely at our command. I also felt that by the high elevations commanded, and by the extreme pureness and brightness of the waters from such a poor sterile country that would never be likely to be occupied by man, our city could be insured the fullest supply of the best of naturally filtered water, *free from all peaty and from all chalybeate taste,* by direct and high gravitation, for ever.

At this stage of my survey I considered that the project was perfectly secure, without any necessity of then inspecting the western slopes of the coast range to the south, which I knew continued on their average rise of 40 to 41 feet to the mile southerly. The pleasures of success, however, goaded me on to see what further waters could be turned from their present southerly courses, backwards to the direction of my proposed northerly channel. This extra part of the work having to be made through a very scrubby country, it was accomplished with the aneroid only by three subsequent explorations of the neighbourhood. At my first of these later visits, the aneroid was set at a point on Westmacott's Pass, which I knew by true measurement was exactly 50 feet above the proposed tunnel mouth, and level with the supposed Lake Loddon when full. I traversed a few miles of the country to the south, with this level being maintained, and I was quite pleased to find how many beautiful brooks we could intercept at that level in a very short distance of barely three miles from the starting point. Some considerable contouring of the creeks and hills had to be done, to gather up, as it were, Knight's Creek, and the three most northerly sources of the Cataract River, but I proved the easy means of getting them all for our purposes. In this short distance alone there was evidence of being able to obtain fine permanent streams, which would be of themselves probably equal, in ordinary seasons, to the present consumption of Sydney. Having fixed various station-pegs to mark the levels along this country at 50 feet over the proposed tunnel mouth, and after determining such levels at these northerly head sources of the Cataract River, I found before me to the south another favourable rise of about 210 feet, in a short distance of not more than half a mile. By this new elevation we came upon another plateau behind Wonona and Mount Kiera, and from thence, at an elevation of 1,380 feet, we commanded a magnificent view to the south of Mount Kiera, Mount Kembla, Mount Wanyanbilla, and the "Saddleback" mountain behind Kiama, besides which we commanded a view of the lowlands by Dapto and Kiama fringed with the yellow sands and white surf of the sea, and a great expanse of the ocean on the south-east, whilst to the westward we had the additional panoramic view of the forests inland towards Bargo, Mittagong, and the heads of the Shoalhaven, which made the distant view surpassingly grand.

The lay of the western slopes of the coast range, then before me to the left or east, gave seeming evidence that we could still continue the advantageous and average rise of 40 feet to the mile, along these slopes right away to Mount Kiera and Mount Kembla, by contouring the gullies and spurs of the coast mountain, should any additional waters be required for Sydney in its future enlarged state. The scrub up there was so troublesome and the

labour of getting through it is so great that I deemed it prudent to beat a retreat, but with the intention of striving to pass through it to Mount Kiera another time. I was convinced, however, from what I saw from the elevation above the Cataract River, that my theory of the application of the great north-westerly dip of the coal basin and country was virtually reduced to practice.

These expectations, I am happy to say, were realized by the result of three subsequent aneroid surveys made behind Wonona and Mount Kiera. Passing some four miles along the top of the coast range from the Bulli Pass to Wrixon's Pass, behind Wonona and Bellambi, I found the level of that gap was about the same as the gap at the Bulli Pass; so much so that I considered that it would require a more perfect survey with the proper instruments to determine the relative height of the two spots; but as we have 40 feet 2 inches to spare at the lowest point of the Bulli Pass, so I estimated that the channel from the south could pass along this depression at Rixon's Pass by bringing it close up to the eastern boundary of the cliffs overlooking Wonona, Bellambi, and the sea. I saw also that should the level of such pass prove to be too low for the channel, it could be easily remedied there by erecting a flume of some 8 or 10 chains long, to be made out of the fine turpentine timber which abounds near that spot, and where there are the remains of a deserted weatherboard building. Or it might be that at this or any other possible depression the so-called inverted iron syphon could be made in substitution for the flume if found to be cheaper, although the wooden flume would nowhere be so safe from running fires.

Thence to Mount Kiera the country rises for some five miles very considerably, until it meets the westerly dividing range, along which the old road from Wollongong to Appin passes. A further aneroid survey indicated that we could lead the channel along and around this country a few hundred feet below the Mount Corrimal, or "Brockersnose," and the Mount Kiera ranges. The westerly dividing range (running at right angles with the coast range) being reached, I found that the channel could be advantageously continued for many miles to the westward under the north side of the Appin Road, and by which all the drainage from the swamps which feed the Cataract River below could be all gathered into my proposed channel, to lead the waters north into Sydney. Beyond this country, I consider that it is quite unnecessary to go in search of more waters for Sydney; but as I have before stated, this western range, which divides the Cordeaux waters from the sources of the Cataract River, could be pierced by a short tunnel of about half a mile; and the further almost illimitable supply of waters from the south could be led north by the continuance of a canal for this purpose, much in the

same way that the Eureka Water Company in California have successfully constructed their race or aqueduct of 250 miles, at a cost of £180,000.

It might be thought, from my present advocacy of the high-level scheme, and from my notes on the face of my map, for the low-level plan from Port Hacking Creek, that I quite abandon the lower for the higher delivery (or gathering) method. It is quite impossible that I should not think much more highly of the one than of the other, after the extraordinary relative results proved and exemplified here by Eitelwein's formula for calculating water delivery and water power.

In advocating the superior high-level scheme, I do not at all abandon the low-level proposals from Hacking Creek—of itself it would have been a grand boon for Sydney, had we not discovered the incomparably greater advantages of the high-gathering plan. I believe that Sydney might have another full supply by gravitation from Hacking Creek alone, by aid of the overflow waters at the intake of the high mains, after those mains were constantly and fully charged, when the spare waters could come on by natural gravitation to the lower levels of Port Hacking Creek, and on to my proposed cement concrete dam in that valley. The time may come when the waters of Port Hacking Creek may be required; the waters to a large extent will be there whenever wanted, and it will then be only a matter of counting the cost of sending such extra supplies by slow gravitation into the lower levels of Sydney and about Botany for household purposes, when a large manufacturing population may spring up there.

It is not for me to project any details of the mode of working my scheme. It is enough that I should give particulars as I have done of the origination of, and proofs of, the value of my discovery. I may be asked what would be the expenses of the scheme? My reply would be that I cannot tell nor could I say what would be the cost of the mains even if we knew what size of pipes would be adopted in the first instance. But this much I would broadly say, in reply to any such questions, that if it pays populations in Nevada to supply their towns and country with water, and with hydraulic force, from high mountains, and by long distances by gravitation, and by wrought iron mains especially, so should it answer our purposes to supply our city and suburbs with abundance of pure mountain waters, exclusively from a sandstone formation, by direct gravitation, and more particularly when the water could be made at the same time to yield mechanical force almost equal to the industrial steam-engine power of the population of Sydney.

I would therefore decline to attempt to make an estimate of the expenses of my scheme; whilst at the same time I will urge

the remark that, be the cost what it might, it would speedily recoup its expenses, and would help immensely to increase the value of property, and to raise the status of our metropolis. It should also be borne in mind, as corroborative proof of the value of such a plan as mine that in London there is now a clamour to have a water supply brought by inclosed mains all the way from the Welsh mountains, distant about 250 miles, because it is found that the contamination of the present supply waters above the intake of the pumps and mains has become a terrible evil, notwithstanding the compulsory filtration by Act of Parliament enforced on all the water-supplies. This being the case in London, and here too (especially by Busby's Bore supply to Sydney), should we not take warning, and avail ourselves of the close proximity of our mountain supply?—when I can inform this Society that the *locale* of my proposed intake of the high mains is distinctly visible from every elevation in and about Sydney, and that the pipes for their longest proposed distance, to the Waverley heights, would not exceed 30 miles.

As this paper should be made as independent of my map as possible, I deem it necessary to transcribe the water power notes as they appear there, and which are as follows:—

"WATER-POWER OBTAINABLE BY THIS SCHEME.

"By releasing the pressure of the duplicate 18-inch mains at the Petersham and the Waverley heights for easier gravitation into Sydney and its suburbs, the water power that would be incessantly available for machinery would (as proved by Eitelwein's formula), be equal to 763 horse-power at Petersham, and 635 horse-power at Waverley.

"If, from the two 18-inch mains, 2,000,000 gallons of water were sent on by a special fire main to the George-street levels in Sydney under the full pressure of 1,000 feet, there would be a certain extinguishment of all fires with the force at command; whilst, by independent pipes from such fire-main, the city might ordinarily avail itself daily of an incessant force, for special machinery, equal to 420 horse-power. In such case the water power at Petersham or Waverley would be reduced; leaving, however, a total large gain of power for twenty-four hours' service every day by this conduit, and extra pressure into the city. The pure mountain waters which would thus be released in Sydney itself, after giving off their hydraulic force, could be led into various positions to afford public baths everywhere on the lower levels, besides supplying shipping, &c.

"From the high delivery of 1,062 feet one single main of 24 inches diameter would bring down 9,524,430 gallons, or 1,224,396 gallons more water each twenty-four hours than two 18-inch mains,

and it would yield proportionably far more water power; the security, however, for a constant supply to the city and suburbs would not be so great as by duplicate smaller mains of greater expense.

"Here it may be mentioned as evidence of the value of high gravitation, that if the full force of the water by only one 24-inch main with 1,000 feet "head," and with even 30 miles of friction and delivery, was brought into the city itself, the force that would be available there by its delivery of 9,524,430 gallons daily would be no less than 2,002 horse-power.

"By the low delivery plan from Port Hacking Creek one large main of 36-inch diameter would not deliver more than 5,417,353 gallons daily into the Crown-street reservoir, and would only yield the insignificant hydraulic force equal to 38¾ permanent horse-power.

"These comparisons favour the having one 24-inch main to begin with, and of laying down on the same line a second main of the same size, as a precaution against accidents, in which case such second main would be available for a double supply (19,000,000 daily) when the city might require more water and more hydraulic force for industrial purposes at Petersham, Waverley, and in Sydney.

"The large extra supply for such purposes could be insured by simply raising the proposed Loddon dam 20 feet higher, and by continuing the supply aqueduct to the western slopes of Bulli, Wonona, and Mount Kiera for some 5 miles further than already projected."—N.B.—See note at foot of section of storm dam.

The water-power notes on the face of the map will be sufficiently chronicled in that form; but as I feared to crowd in too much matter upon the map, I would desire to attach to this paper one more very interesting and important note, to show the practical effect of sending down waters to Waverley, Petersham, and Sydney by only one 24-inch main.

The water which would be delivered at Waverley, Petersham, and Sydney by one 24-inch main, branching off at Cook's River into other pipes for Petersham and Waverley, would be, giving Sydney 2,000,000 gallons daily for fire-mains, as follows:—

Waverley ...	3,300,132	gallons daily	For Sydney indirectly.
Petersham ...	3,740,150	ditto	
Sydney ...	2,000,000	ditto	for Sydney direct.
	9,040,282		

This is the result of three pipes to Waverley, Petersham, and Sydney respectively, whilst the horse power would be:—

Waverley	H.P. = 520·32
Petersham	H.P. = 651·70
Sydney	H.P. = 420·00
	1,592·02 H.P.

This is the result of three pipes to the three places as above, and fed from the one 24-inch main from the high-level point of 1,062 feet. I think that, after showing such extraordinary results in both the water delivery and water power given from so small a pipe under high pressure, no one can be sceptical enough to doubt the efficacy and economy of such a mode of water supply.

By my former paper, read here on the 9th of December last, I based all my estimate of water supply to Sydney by the use of two 18″ mains from high level. The subsequent surveys having given such extended prospects of an increased supply, and the economy being so greatly in favour of the adoption of larger pipes, as shown by the above notes, it need not be a matter of any surprise that I now advocate the use of one 24″ main to begin with, in terms of my present paper, and that such one main should be followed by another of similar size as soon as practicable.

In my proposal for conducting the wrought iron mains overground by the easy gradients of the Bottle Forest Road down to the sea level of George's River, I have considered that such gradients for the pipes can be made to be so regular in their declension to the crossing of George's River by the proposed railway bridge for the Illawarra line, that the line of pipes would probably be in almost one continuously straight direction, owing to the gradual depression of the country from the starting point of the mains at 1,062 feet, down to the sea level at George's River, distant about 17 miles. Assuming that a future survey of this line should prove the correctness of this statement, considerable advantages will be given in the construction of the wrought iron overground aqueduct, as compared with a similar work in Nevada from Martella Lake, over hill and dale, to Virginia City and Gold Hill, a work which has been carried out so successfully in the short space of five months over a distance of more than 10 miles, to cross the waters over a mountain valley that is 1,750 feet deep and 7 miles across, and where the wrought-iron pipes are bearing at the bottom of the deep valley the unprecedented pressure of 750 lbs. to the square inch.

Should this high-gravitation scheme become adopted, the construction of the wrought-iron aqueduct could be rapidly dealt with by engineering firms in Sydney; one of which, I am informed, could undertake to construct by steam machinery one mile

of such iron mains per week, if required. Should this system of water supply be gone into, I would advocate the adoption of stop-valves at every two miles, so as never to make it necessary to empty more than that length of mains to get at possible repairs. I would also advocate the use of self-acting air-valves at the apex of all bends in the pipes, so as extract any air that might impede the free flowing of the waters, and also by this ingenious principle to introduce air into the pipes when required to prevent concussions and collapses by partial vacuums created when the waters may be shut off anywhere along the mains. For interesting particulars of these important self-acting air-valves I refer you to the *Engineer* of the 3rd of April, 1874, in which the new waterworks in wrought-iron mains for Virginia City and Gold Hill are fully described.

On this part of the work I would desire to point out that my proposed overground mains on sleepers would pass through an entirely uninhabited and waterless country along the crest of the dividing range which separates the watersheds of the Waranora and the Port Hacking Creek waters. The effect of this would be that such aqueduct could be tapped anywhere along the line to supply reservoirs for the reclamation of large tracts of Government and of private lands, which would be almost in sight of the proposed Illawarra Railway route; and thus this water conduit for Sydney would go hand in hand with such railway to form extensive additional suburbs to the city—and thereby tend considerably to recoup the Government in the outlays for such national works, whilst at the same time the immense water power that would be available for leasing would alone go very far towards paying the interest on the capital to be invested in the proposed high-gravitation water-scheme for the supply of Sydney.

I must not pass over this part of the proposed water conduit by the wrought-iron mains, without informing you that for some five or six miles along the gradual deflection north of the Bottle Forest Road, and, at about the centre of it from George's River to Madden's Plains, the surface of the country is covered with ponderous and rich clay ironstone ore, which overlies the upper seam of coal at some 500 to 600 feet. Here, then, we should have at our command another of our biggest elements of future wealth, when the Illawarra Railway should pass close by to unite coal, iron ore, and water for one common cause to render that now untenanted country available for future industries.

And now I must crave your forbearance for a divergence from the main subject, to express my thoughts for similar advantages which could be made available in another direction of these proposed waterworks. During my late surveys, I saw with what facility the waterless town of Wollongong might be supplied with pure water, to any extent that might be required, by means of

tapping the open channel from behind Mount Keira, when this canal, if made, would necessarily pass quite close to the top of the cliffs at Rixon's Pass, or gap behind Wonona and Bellambi, and which Pass is about 1,160 feet over the sea; from thence it is about seven miles to Smith's Hill at Wollongong, where I found that hill was 130 feet over the sea. From the main channel, on the top of the mountain at Rixon's Pass, a small wrought-iron pipe might be laid to connect with a receiving and distributing reservoir on the apex of Smith's Hill, which would command the whole of the town of Wollongong for reticulation of service pipes. The plan is so simple that it would resolve itself only into a question of expense for the supply of that town and suburbs, should it become sufficiently important under proposed railway development.

With such head of water on to Smith's Hill, reckoned at 1,000 feet, the delivery by a 9-inch pipe in wrought iron would be no less than 1,497,240 gallons each twenty-four hours, or say 1,500,000 gallons of purest water, which would probably be more than a week's supply for the town of Wollongong, whilst at the same time the release of the hydraulic pressure of so much water deliverable in twenty-four hours into the distributing reservoir on Smith's Hill would afford the townspeople there no less than 315 horse-power available for local industrial factories for constant day and night use as long as the water was on. Of course a very much smaller pipe and supply would suffice for Wollongong as it is; but I give the working of a 9-inch pipe, in order to show the effect and what could be done for the place by these measures under such advantages, always provided that the main supply in the aqueduct above was made equal to such extra demand upon the general consumption; and which certainly could be ensured in all seasons by tunnelling under the old Mount Keira Road, and continuing the main channel further and further south along the western slopes of the rising coast range, which gradually rises up to 1,745 behind Kiama, and to 2,000 at the extreme south part of the great coal basin, some 6 miles further on towards Broughton's Creek and Shoalhaven.

In my former paper I touched upon the great importance of coating the inside of the wrought iron pipes in such a manner as to ensure them against corrosion. I desire to repeat this remark, lest I might by some be considered to have overlooked this point. In Nevada this is done by immersion of the pipes into a mixture of boiling asphalt and coal tar; but the great importance of making the inner wall of the main perfectly safe against corrosion, and freed from all risk of a coal-tarry taste to the waters, would seem to warrant the adoption of a comparatively dearer though cheap system of enamelling by the use of certain resins dissolved in cheap methyllated spirit to be applied and to be burnt on the

inner part of the pipes at the time of the construction of the same. Wrought-iron mains of 4-16th of an inch thick, if not properly protected when under use for water conduit, would corrode through in about fifteen to twenty years even without pressure, whilst with pressure, such as my scheme would impart, the pipes would probably become worthless in less than ten years. I would therefore advocate enamelling from the first for the inner coating, whilst the outside could be perfectly protected by an annual painting over with inferior residue oils from the kerosene works.

I have before stated that my scheme embraces no attempt at any system of irrigation, because it is quite impossible to supply waters for such purposes cheap enough, where iron pipes are necessary for the conduit of the waters. If irrigation can be made use of for the county of Cumberland in this Colony, it can only be by the very costly and dangerous erections of immense dams to throw back almost inexhaustible supplies of flood waters, in manner as has been undertaken lately at Poonah in India, and at Furens by St. Etienne, in France, both built in solid masonry bedded with liquid cement.

By my scheme, and along either the high or the low level gathering-grounds, I am satisfied that very vast bodies of water, even for extensive irrigation, could be obtained and impounded by means of the erection of high dams. But *cui bono?* When such supplies could not be conducted to arable or pastoral lands without the application of expensive iron mains, or by circuitous and very long open channels, that would never repay interest on the cost.

But even if the expenses were not alone a sufficient drawback to the erection of high enbankments for such purposes, I have gathered sufficient information on this subject to deter me from like advocacies. In the report on the "Ballarat Water Supply Extension," drawn up by Mr. G. Gordon, the able Engineer-in-Chief for Victoria (and who was sent down from Madras under the recommendations of Colonel Sankey, an equally talented hydraulic engineer), I observe some valuable remarks on the subject of high enbankments, which I will here quote. At paragraph 15 he says—"It will not, I think, be denied that there is considerable risk attending the construction of large embanked reservoirs. Although there is no difficulty in designing a bank which will theoretically be able to retain 100 or even 200 feet of water, the risks of failure increase in a greater ratio than the square of the height. It is no disparagement of the skill of any engineer to state that fact, nor will any one who has experience in making high dams be inclined to make light of it." Mr. Gordon, in support of these views of his own, quotes several apt passages from evidence given before a Committee of the House of Com-

mons by various able engineers, in the persons of Hawksley, Rawlinson, and Bateman.

I lately had the pleasure of meeting Mr. G. Gordon, of the Victorian Water Supply, during a recent visit to Melbourne. This gentleman not only deputed one of his own officers at the Yan Yean Waterworks to show me everything connected with that fine supply for and delivery into Melbourne, by its embankment of 48 chains with maximum depth of 1,200 acres of water at 25 feet, but he also most kindly undertook to accompany me afterwards to the western waterworks at Malmsbury, 63 miles from Melbourne, known as the Coliban Waterworks. From thence he took me on still further to witness the interesting method of crossing the supply waters for Castlemaine over the valley of the Back Creek by means of the so-called inverted syphon composed of a 36-inch cast-iron main, which conveys the channel waters underground across a valley that is 114 deep, and nearly half a mile across from water-level to water-level. The Castlemaine end of the pipe is depressed 6 feet below water-level, to admit of a free outflow of the waters into the channel.

I need scarcely say how interesting these inspections of the Victorian Waterworks were to me, whilst made under such very favourable circumstances. I cannot speak too gratefully of Mr. Gordon's kindness in affording me such instructive and pleasurable advantages. Mr. Gordon favoured me with a complete set of his own and predecessors' official reports on Water Supply, which I have now the pleasure to present to this Society, after having gleaned much information from them in connection with my own present work and attempt at usefulness in same direction.

I have also to record another very obliging act of kindness of Mr. Gordon's in his having since furnished me with working plans of the cement concrete dam that he has recently built at Stony Creek for the Geelong Water Supply. These plans are also accompanied with descriptions of the method of constructing that dam, together with the cost of the work, &c., all of which I am authorized by Mr. Gordon to use in connection with the publication of my present paper. I may add that, on presenting Mr. Gordon with a copy of my water-supply map, together with a copy of the paper containing the translation of Delabar's paper on Ritter's great Freiburg Waterworks, he exclaimed with pleasurable surprise when he saw the diagram showing the section of Ritter's cement concrete dam, inasmuch as he had not been aware that any one else had made a similar embankment, although his own design is on the principle of the building of the Furens dam, though slightly modified. Mr. Gordon's cement concrete dam at Stony Creek was commenced before the similar embankment was finished at Freiburg. The Freiburg dam took two years to complete, whilst the much smaller one at Stony Creek,

Geelong, took eighteen months in building, and was made at a much greater expense.

I have much pleasure in presenting to this Society the valuable plans and descriptions sent to me by the Engineer-in-Chief of the Victorian Waterworks, and which I would suggest should be attached to this paper as an appendix to the same (for which they were kindly and specially prepared by Mr. Gordon). My belief that this extra information from so able an engineer, when coupled with the published description of Ritter's similar work in Switzerland, may go far to school our minds into the knowledge that the apparent costliness of these works is as nothing compared with the great advantages that would accrue to the public from their adoption, and that by making people familiar with the idea of costly works they will at last come to consent to their being entered upon. With such hope before me, I will leave the subject in other hands, and retire from it myself.

APPENDIX.

" The Stony Creek dam for the Geelong Waterworks in Victoria was designed by Mr. Gordon, the hydraulic Engineer-in-Chief for the Waterworks of that Colony. This gentleman kindly furnished me with the plans and with the following descriptions of the work.

The dam is on the method introduced by the French engineers, MM. Graef and Delocre, from whose designs the great dam at Furens was built. It is known as the system of equal pressures, it being so calculated that the pressure at the rear surface shall not exceed and not fall short of a certain pressure per square foot, when the reservoir is full, nor at the front surface when it is empty. In this case the limit is 8,000 lbs. to the square foot. The top, however, and for some distance down it, is theoretically too thick ; it ought to come to a sharp edge at the water line, which would be inconvenient.

It is built of concrete, made of sandstone, metal, sand, and Portland cement. The following proportions were found the best :—

2 metal, $3\frac{3}{4}$ parts ; screenings, $1\frac{1}{4}$ part ; sand, $1\frac{1}{2}$ part ; cement, 1 part.

The contents are 5,096 cube yards. The cement and sand were first mixed and made into mortar, and the other ingredients were then added, the whole being constantly turned over in a mixing-trough similar to a " buddle," driven by horse-power. The surfaces are plastered with cement mortar.

The greatest height is 67·6 feet, the height above the scour, which is near the old creek level, is 53 feet, and the outlet is 9 feet higher than the scour. The thickness at the level of the scour pipe is 38 feet, and at the top, under the coping, 2 feet 6


TRIAL SURVEY
FOR A
WATER SUPPLY FOR SYDNEY
BY GRAVITATION.
By Mr James Manning,
October, 1874.
SCALE OF CHAINS.
NOTE.—This survey, with the level and staff, was brought up from the sea level at Bulli, by Westmacott's Pass, on the road from Wollongong to Appin and Sydney. The true levels of the survey, as shown by this map, extend only for about 3 miles along the coast range to the south-east of the proposed Loddon dam; beyond that point to the south the country is so scrubby and broken that the further survey had to be confined to aneroid observations taken during three different and separate visits to that country. These observations have been made with full effect to prove the entire practicability of leading all the upper sources of the Cataract and Cordeaux River waters direct to Sydney viâ Mount Kiera and Westmacott's Pass to the proposed tunnel mouth, and to such an effective extent as to show that a fine new river might be led that way north, in all seasons, for Sydney supply by high gravitation, and thus enable us to make the large extra supplies of water of the Loddon, the Madden, the head waters of the Waranora and the Port Hacking Rivers to be only supplementary to the supplies from the greater watersheds of the south coast range, although such supplementary waters might alone be more than sufficient to supply the demands of the city in perpetuity.
WATER POWER OBTAINABLE BY THIS SCHEME.
By releasing the pressure of the duplicate 18-inch mains at the Petersham and at the Waverley heights for easier gravitation into Sydney and its suburbs, the water power that would be incessantly available for machinery would (as proved by Molesworth's formula), be equal to 763 horse-power at Petersham, and 635 horse-power at Waverley.
If from the two 18-inch mains 2,000,000 gallons of water were sent on by a special fire-main to the George-street levels in Sydney under the full pressure of 1,000 feet, there would be a certain extinguishment of all fires with the force at command; whilst by independent pipes from such fire-main, the city might ordinarily avail itself daily of an incessant force, for special machinery, equal to 420 horse-power. In such case the water power at Petersham or Waverley would be reduced; leaving however a total large gain of power for twenty-four hours service every day by this conduit and extra pressure into the city. The pure mountain waters which would thus be released in Sydney itself, after giving off their hydraulic force, could be led into various positions to afford public baths everywhere on the lower levels, drinking water for shipping, &c.
From the high delivery of 1,062 feet one single main of 24 inches diameter would bring down 9,524,430 gallons, or 1,224,396 gallons more water each twenty-four hours than two 18-inch mains, and it would yield proportionably far more water power; the security however for a constant supply to the city and suburbs would not be so great as by duplicate smaller mains of greater expense.
Here it may be mentioned as evidence of the value of high gravitation, that if the full force of the water by only one 24-inch main with 1,000 feet "head" and with even 30 miles of friction and delivery, was brought into the city itself, the force that would be available there by its delivery of 9,524,430 gallons daily would be no less than 2,002 horse-power.
By the low delivery plan from Port Hacking Creek one large main of 36-inch diameter would not deliver more than 5,417,353 gallons daily into the Crown-street reservoir, and would only yield the insignificant hydraulic force equal to 38¾ permanent horse-power.
These comparisons favour the having one 24-inch main to begin with, and of laying down on the same line a second main of same size as a precaution against accidents, in which case such second main would be available for a double supply (19,000,000) daily when the city might require more water and more hydraulic force for industrial purposes at Petersham, Waverley, and in Sydney.
The large extra supply for such purposes could be insured by simply raising the proposed Loddon dam 20 ft. higher, and by continuing the supply aqueduct to the western slopes of Bulli, Wonona, and Mount Kiera for some 5 miles further than already projected. N.B. See Note at foot of Section of Storm dam.
SUPPLY AQUEDUCT FROM MOUNT KIERA.
The lowest point of the Southern Coast Range above Bulli, known as Westmacott's Pass, would necessarily have to be traversed by the aqueduct from the south, to contour the hills there as high up as possible on its course to the tunnel mouth, which would be about 3 miles distant from such pass. Such lowest point is by the roadside, and is 1,161 ft. 1 in. over sea level; it would be 40 ft. 2 in. above the proposed tunnel entry, but 10 ft. below the level of Loddon Lake when full, consequently the southern waters from Knight's Creek, from the four main sources of the Cataract River, and from all the streams further south along the western slopes of Wonona and Mount Kiera, after being led on by the proposed aqueduct, could not enter the proposed Loddon Lake, but could supply the tunnel direct, amply for Sydney demands, and leave the Loddon Lake waters (estimated at 2,000 million gallons) in reserve to subsidize short supplies by the south aqueduct, by the Loddon Lake overflow, by the Maddens Creek shaft, and by the Head of the Woranora, in very dry seasons.
The tunnels and canals would all have gradients of from 4½ to 5 feet to the mile.
Overground Mains.
If two wrought iron, or steel mains, of only 18 inches diameter are applied at this high elevation of 1,062 feet at point A, the pressure could be borne with perfect safety, and the velocity of the water delivery would be so great that no less than 4,270,891 gallons, with the 850 pressure, could be delivered daily into a reservoir on the top of the Petersham and Canterbury heights, by one pipe; and to the highest point at Waverley, with 750 feet pressure, no less than 4,029,143 gallons daily by the other. In all, these two small pipes would deliver (by Eitelwein's formula) 8,300,034 galls. daily. Present Sydney requirements and supply in Summer 5,000,000 daily
These mains would be in three series of strength, according to the altitude of and the pressure on the pipes, namely by boiler plates of 2/16ths 3/16ths and 4/16ths of an inch, in ratio and application same as at the Nevada Waterworks where a pipe of 5/16 ths of an Inch bears the enormous pressure of a head of water of no less than 1750 feet, which is equal to 750 lbs. to the square inch.
Lower Supply Service from the Port Hacking Rivulet.
At about six miles from point A, down the Port Hacking Creek, and about 24 miles from Sydney, and from an elevation of 170 feet, another and large wrought iron main of 36 inches diameter could be laid on to the Crown-street Reservoir, where, with only 34 feet pressure, a further delivery of 5,417,533 gallons daily could be made in all seasons. In all, including high service deliveries, equal to 13,717,567 gallons daily, as computed by Eitelwein's formula.
N.B.—In order to keep up this immense additional supply to Sydney by means of the low level delivery from Port Hacking Rivulet, it should be understood that a dam of 50 feet high, in concrete, would have to be made across a narrow gorge, and at a most favorable spot in the Hacking Valley, where the level of the rivulet is 120 feet over sea level, and from whence the low level main would have its entry for the waters of Sydney. Such a dam would be for the double purpose of giving a direct increased head of water to save 105 chains of elongation of the expensive main; and also for the purpose of storing a further immense supply of water in case of any excessive drought, as such dam would throw back a lake of water which would be about one mile and 25 chains long
LAKE LODDON
(AS PROPOSED)
1171 feet over sea level
The Lake is 7¾ miles round, and the area is 366 ac.
This Lake is Estimated to contain 400 days supply for Sydney at 5 Millions galls per day.
This Tunnel would be 3 miles and 35 chains long, excavations for it can be made by 5 short Shafts, besides by both ends.
The direct course between the extreme points M and A only 5¾ miles
MADDENS PLAINS
Bottle Forest Road
Perpendicular Cliffs of Coast Range
Rice's Falls
55 feet perpendicular
to George's River
Head Waters of Woranora River
going into George's River
Course of Open Canal
Course of Canal
STORM-WATER DAM
Every Creek marked on this Map is a permanently running stream.
Section of Storm-water Dam on Maddens Creek.
Scale of Chains.
N.B. It is to be understood that Dams of this kind (with concrete cores only) would have to be made everywhere along and above the Southern Aqueduct, where the levels would admit of them, with a view to exceptional supplies
Section of Dam at Letter L, consisting of one Main Dam and two Wings
(From Lake side)
Scale of Chains
Northern Wing bearing 5° W.
Southern Wing bearing 86° E.
This Dam would have to be built in solid cement concrete, in same manner that the Engineer, Ritter built the great Dam at Freiburg in Switzerland, for the Waterworks there; and it would have to be built with such a rough surface on the top of its 50 ft. level that it would be ready at any time to be raised upon for 20 ft. more
This is the starting point of the Survey: it is on the Sydney and Wollongong Road, about 3 miles from Stanwell Park northwest. It is 1062 ft. over the sea.
Distance to Sydney from point A, about 28 miles.
Head waters of Port Hacking Creek
Inlet to the Mains
LOCAL SKETCH
Scale of English Miles
PACIFIC OCEAN
BOTANY BAY
Port Hacking
Port Jackson

inches. The length is 226 feet, and it is curved up stream, the front face being convex, to a radius of 300 feet. There are two valve houses, also built of concrete.

The dam is perfectly tight, and this is due to the extreme care taken by Mr. Dobson, the engineer, and Mr. Brown, the inspector in charge, with the testing of the cement and the mixing of the concrete. It was constructed by day labour, with the exception of the coping. The concrete was put in in 7-inch courses, and well rammed. It cost £3 8s. per cubic yard, including every expense except the engineer's salary. The total cost was £17,306 12s. Labourers were paid 6s. 6d., masons 10s., and plasterers 8s. per day. Cement cost 31s. per barrel. The outlet pipes are of cast iron, bedded in the concrete. The work was begun in January, 1873, and finished up to the coping in June, 1874. The reservoir contains 141 million gallons, so that the cost of storing is £122 15s. per million gallons. The rock on which it is built is sandstone, but slate with quartz leaders appears in the creek bed, and there the stone was much crushed, which necessitated a greater depth for the foundations than was anticipated."

[Three plans.]

METROPOLITAN WATER SUPPLY.

By Mr. James Manning.

[*Read before the Royal Society, 2 September,* 1875.]

Mr. Chairman,—Before the discussion on my last paper commences I would request the privilege of annexing a few remarks, the omission of which renders the description of my gravitation scheme incomplete.

Some persons may think that the great pressure of 1,000 feet in the proposed fire-mains all over the city to be given as a protection again the spread of fires, and for the purposes of obtaining special water-power, would not compensate for the risk of damage that might be done by possible fractures in the mains, were they made ever so strong in wrought iron, and secure by means of abundant stop-valves. I was induced to embody such proposal in my scheme by having ascertained that in Melbourne the water-pressure of only 300 feet from the relieving reservoir from Preston, seven miles from Melbourne, is quite insufficient to afford water power in that city for anything more than for a few hydraulic lifts, &c. I was told there, that they now wanted much higher pressure than they have from their present head of water, and by means of their mains of cast-iron. Hence the reason for my advocacy in this direction for ourselves, whilst my high-gathering scheme gives a complete command of such advantages.

On the other hand, it may be considered by some that if Sydney was served wholly from the proposed Waverley reservoir of 300 feet elevation, we should have exactly the same pressure as they now have in Melbourne, and which is known to be adequate to all ordinary purposes, and is enough to be a fair safeguard against conflagrations, and that then the ordinary mains for serving our city would answer all purposes; whereas the fire-mains under the very high pressure proposed would require separate and special reticulation of their own.

Some persons may also consider that as Sydney is soon likely to be served with cheap coal direct from the southern mines, the special water-power for our city could be more readily dispensed with here than for Melbourne. I trust, therefore, that these are considerations worthy of notice, whether the laying on of a direct fire-main from the bifurcation of the pipes at Cook's River into the city be determined upon or not.

Also, I have to remark that as the proximity of St. Leonard's, across our fine harbour, to the business parts of Sydney, will insure a rapid extension of population there, so we should bear in mind that such future large suburbs will require a good water supply; and as I am confident that no proper supply for that locality can be obtained from the North Shore side, so may we at once fairly contemplate our ability under my scheme to send on the waters there from Sydney, by continuing the high-pressure main across and under the salt water of the harbour, with the view of supplying a receiving reservoir on the highest point of its neighbourhood—a desideratum which would be obtainable there in such cases during the hours of night, when the machineries in Sydney, driven by water engines, and by turbines, would be at rest, and not consuming the water from the high-pressure main.

And failing the application of the high pressure mains for the service of all the North Shore, we could under my scheme, and in same manner, supply a receiving and distributing reservoir there, at an elevation nearly as high as could be commanded from the proposed relieving and distributing reservoir at Waverley.

It is, however, particularly noteworthy that a water delivery in pipe, by the bottom of the harbour across to the heights of the North Shore, would be far easier, safer, and less expensive by the high pressure than by the low pressure plan. By the high pressure a singularly small pipe in spring-steel, or in iron with elastic joints, enamelled inside and outside, and lowered to the bottom of the harbour, would supply a large population with abundance of pure water; whereas it might be very difficult to place, in a similar manner, the far larger pipe to do the same duty under a sluggish delivery by the low pressure plan from the Waverley reservoir.

On the vexed question of adequacy of watershed and water supply from my proposed gathering-ground, or indeed from any gathering-ground, I have just received the most valuable information from Mr. G. Gordon, the Hydraulic Engineer-in-Chief of Victoria, who, in reply to a recent question of mine, words a part of his letter to me in the following manner, and which I feel at liberty to use for our own general information. Mr. Gordon writes thus:—"I am sorry that I can give you no gauging of the flow of the river Plenty that would be of any use to you. The discharge is so much beyond the requirements of the Yan Yean that the river has never been regularly gauged except at its lowest state. It has been as low as 1,800,000, and on one occasion, I am told, as low as 1,000,000 gallons in the twenty-four hours; of course that was in the height of summer. From some observations of other rivers I find the total discharge to be 136 millions of gallons per square mile per

annum; but of course every basin must be judged by itself, taking into account rainfall, the nature of the soil, temperature, and many other considerations. Observations of actual *discharge* for a year or two, with a comparison of the rainfall of the years observed, with the average registered rainfall, &c., are the only guides in estimating the probable yield of any watershed.

"There has never been any scarcity of water in the Yan Yean reservoir. I suppose the annual consumption may be taken at 3,500 million gallons, or somewhere about 54 million gallons from the square mile; so that a great deal more than half the water may be supposed to run to waste, that is, sent down the river and shut out from the feeding channel of the Yan Yean reservoir.

"Roughly speaking, I should think that you would require from 80 to 100 square miles of drainage area to supply 200,000 people, supposing the rainfall to be 35 inches and the country moderately well suited for discharging a fair proportion of it."

By this letter I derive more and more confidence that the watershed and supply from my proposed gathering country is equal to the gathering ground for the fine Yan Yean supply, added to which we have to remember that against the average rainfall in Victoria of 35 inches, we have, even at our "South Head" at Sydney itself, an average rainfall for the past sixteen years of 52·375 inches, whilst on the sources and country of my supply I doubt not that the average rainfall exceeds 60 inches. Therefore, with my knowledge of the available watershed, as proved by my survey as far as Reeve's Creek, south, I could only consider it to be quite puerile to question the superabundant water supply at our command for my high gathering and gravitation scheme for any amount of population that may hereafter grow up in Sydney and its suburbs.

With these general remarks to be attached to my late paper, I now resign my water supply scheme into your hands.

WATER SUPPLY TO SYDNEY BY GRAVITATION.

By Mr. James Manning.

[*Read before the Royal Society, 8 October*, 1875.]

Mr. Chairman,—Before I proceed with the purpose of this additional paper on the subject of water supply by gravitation, I desire to tender my thanks to the Council of this Society for giving me the privilege of making more deliberate replies to the remarks and objections made to my project for water supply than it was possible for me to have in making impromptu answers to the various speakers who discussed the subject on the occasion of our last meeting. Nothing but the extreme importance of this really vital matter would warrant my addressing this Society once more even in reply. I therefore trust that I may be pardoned for my seeming importunity.

Discussion on this subject has pointed out many sources of objections to my plan, which I could scarcely have anticipated, because of my familiarity with the localities, and of the careful survey which I have made of the water supply country, and the consideration which I have devoted to the subject at issue. For the sake of others, however, I am glad that certain doubts and objections have been raised, as they give me the opportunity of perhaps allaying fears that the boon that I have said is at our command is not a myth.

Among other objections the one prominent one of insufficiency of my proposed supply of water was raised. To such an important matter I would like to reply that my survey was carried out with such care that I can repeat with perfect confidence all that I have stated, namely, that my levels, my measurements for impounding areas, and my estimates of watershed, and for water supply, and for water power, are all perfectly reliable for their accuracy, as far as my survey with the level and staff went, as before noted.

Before I expatiate a little more on the vexed question of the insufficiency of the watersheds and of supply waters for my scheme, I would wish to remark that the report of the late discussion, as it did then take place, made no allusion to our much-esteemed Vice-President's confirmation of my statement of the existing north-westerly dip of the south coast Illawarra ranges.

This is the head and front of my whole scheme for bringing the waters in an almost direct northerly course to Sydney from as far south towards Shoalhaven as we might choose to go with our aqueduct, ditch, or canal, to supplement the water supply to any extent that might be required. The Rev. W. B. Clarke, our Chairman, then said that such dip from the south equalled 42 feet to the mile, whereas I had only stated it to be 40 to 41 feet. This being the leading point of the whole value of my discovery and scheme, I desire to lay stress on this fact, as it is probable that this interesting geological truth was not known to many even of this Society, before this late proposed application of the valuable dip of the coal formation for our uses was made known.

The practical result of this application is, as we all knew before, that it is *quite easy to lead water down hill*, especially when the broken interruptions of the average downward dip of the country to the north, can be so easily overcome by taking further advantage of the westerly dip of 60 feet to the mile all the way, whereby the waters can be made to contour the obstructing ranges almost everywhere without the necessity of tunnelling through the hills, excepting through that region which constitutes the apex of the dividing watersheds of the Cataract River, the George's River, the Waranora, and the Port Hacking Creek waters, where my proposed tunnel of $3\frac{1}{2}$ miles would be to unite the head and permanently running sources of all these waters.

It was on the southern lower levels of these dividing ranges that I found the grand basin for the accumulation and storage of an immense supply of water, as shown by my map, and as described in my late paper. By or into this basin, and by or into the tunnel and open canal that lie west and north of my proposed dam, and which reach the intake of my proposed wrought-iron mains for direct gravitation to Sydney, I estimate that we can command a watershed on this highest ground, close to the sea, of not less than 15 square miles of a swampy country; and as the rains in this region are even more abundant than they are lower down, so I can see no reason to doubt that the rainfall there might be set down to average 60 inches per annum as against the average fall for the last sixteen years in Sydney, of $52\frac{1}{3}$ inches; and that as this upper country is so peculiarly and favourably formed for the delivery and catchment of this great rainfall, so I think that we might safely count on being able to secure for Sydney use the one-half of all that is supplied up there by nature.

Assuming that this estimate may be correct, we should in such case still show from this small watershed of 15 square miles, no less a catchment and delivery for the year for Sydney than 6,534,000,000 gallons, which would be equal to a delivery of no less than 17,901,000 gallons per day, or a quantity from thence

alone capable of supplying two of my proposed 24-inch diameter mains and all this vast body of water would be obtained from within 34 miles of Sydney, where the Loddon dam and tunnel mouth would be situated. This great supply would be without the further accession of an indefinite quantity of water that would be available by my proposed south aqueduct, which would lead its waters into the tunnel mouth ; and by which channel we could have a further large drainage for Sydney above the level of the tunnel mouth (1,121 feet over the sea). But I can see no use of extending the south aqueduct, beyond perhaps a few miles along the almost illimitable watersheds, and by expensive means, when we can have an abundance of the purest waters much nearer home, and at a comparatively very small cost.

If my proposed Loddon dam was raised to 70 instead of only 50 feet, as designed by myself, it would I believe impound quite as much water as the Yan Yean Lake of 1,200 acres, which, when full at its maximum depth of 25 feet at the valve house, contains 6,000,000,000 gallons. But there is no advantage in having such an immense storage until Sydney expands considerably. My proposed cement concrete dam of maximum depth of 50 feet across a very narrow pass or gully and at the confluence of four permanently running streams, would store a supply of water such as I show in Lake Loddon on my map, and which would not be exhausted by Sydney by anything like its present demand, especially if the four neighbouring brooks, south of the tunnel mouth below the dam, were led into the tunnel.

The Sydney watershed contains only 7 square miles ; and yet the City Engineer has constantly remarked on the great discharge into the sea of waters that could not be retained by the sand dams, and that were in excess of the regular supply for the engine pumps for Sydney consumption. It is not improbable that quite as much runs into the sea as is sent up to Sydney. This being the case, we have only to consider, for a conclusive result, that my proposed first storage and nearest gathering ground north of the Loddon dam commands quite double the area of the Sydney watershed, and by a wetter region, and that by the remarkably advantageous features of the country, all the discharge waters could be retained with certainty and at a comparatively small cost.

Under this knowledge of the existing watershed and of the extraordinary facilities of storing the discharge of its rich water supply, how can I do otherwise than regard all counter alarms on my assertions of the adequacy of the supply as being otherwise than imaginary ?

Doubts have been entertained about the purity of the waters in that high locality, and I was asked if I had had the waters analyzed. I replied that I considered that the waters were so

pure there that an analysis of them would be quite surperfluous. As much strain has been laid upon this subject, I desire to enlarge somewhat upon it for your satisfaction. The waters of that region come from the heavens perfectly pure, and from over the sea. They fall on a barren sandstone country, free from all mineral impurities, or at most meeting here and there only with "orchry pans" of small extent, caused by the partial mixture of ferruginous and peaty matter, but existing in such small quantity as not to discolour the waters, and which waters are found to be so clear in the waterholes around that the smallest objects are plainly discernable at various and considerable depths. Knowing this I should as soon think of having waters analyzed that would be caught in a clean wash-hand basin from the clouds up there; neither could I propose to ascertain how many grains of solid matter existed in each gallon of such truly crystal water which passed through nothing but silica and light vegetable matter until it reaches its storage in the lake, or delivery position at the iron mains near at hand.

Questions and doubts were also raised as to the retaining capacity of the sandstone underlying the proposed basin or lake. It was supposed that its porosity would endanger exhaustion. I am sure that such fears are quite without cause. The great basin that is at our command for the formation of the storage lake, is covered with swamps all over and in every direction, on the east as well as on the west, north, and south side, which marks its features for retaining water; and I am convinced that the Loddon valley, if shut in by a cement concrete dam at a spot marked and measured by me, would present one of the finest reservoirs ever produced by nature, and available for man at the least possible cost, and at an elevation (when full) of 1,171 feet over the sea, and distant about thirty-two miles only from Sydney. As regards the porosity of the sandstone of that country being such as to endanger its retentiveness of water, I should never think of such results, care being taken of course to sink for proper foundation for the cement concrete dam. Perhaps the best answer that can be given to such an apprehension would be to inform you that the dam at Freiburg, which is quite impervious, is built on and over a sandstone country of the Jurassic formation called "molasse," which is likely to be more porous than our coal sandstone of the Loddon country, as it is from the molasse that the best stone filters are made. Neither can I suppose that the cleavage of the stratifications could affect the retaining qualities of this grand reservoir there.

Having this unexpected opportunity of explaining a little more of the nature of my proposals for leading the waters from the high gathering ground on to Sydney, I would wish to explain that, although I unswervingly advocate that the intake of the

waters by the iron mains should be at the highest point obtainable, in order to preserve the fullest hydraulic pressure, of so much value, yet I would state, that it would be easy to lead the waters along by an open aqueduct for many miles down the gradual declivities of the Bottle Forest Road, and its marginal eastern slopes on Hacking Creek side, until any other required elevation over Sydney was attained before confining the waters in the closed wrought iron mains. But as such an arrangement would be a violation of my high pressure principle, I do no more than name the feasibility of conducting the waters by open gravitation to within 6 miles south of George's River, where the elevation is 400 feet, and sufficiently high to command the Waverley heights, or the highest point about Sydney. But a proper survey of this part is necessary to determine the feasibility of this part of the conduit.

Of the George's River waters I wish also to say that should the Illawarra direct railway become a fact, and my gravitation water scheme meet with favour and be adopted, I would like to see that the aqueduct for my proposed wrought-iron mains should be so constructed as to form by it a viaduct over the George River for the railway, if the line crossing there should be practicable. I would suggest in this case that such viaduct and aqueduct should be by crossing the river at Kangaroo Point, where it is narrowest, and where embankment materials are inexhaustible—instead of making the railway to pass by the bridgeway and embankments as at present surveyed for the line lower down the river.

Should this idea meet with favour, I would further suggest that such road and water-way at Kangaroo Point should be constructed in the simplest possible form of small broken sandstone, sand, and clay, to be thrown into and across the river to the cubical extent or measurement of about 350,000 cubic yards; and then, by closing the river up altogether (with the protection of an adequate by-wash), and by raising the dam only slightly above high-water spring tides, it would, I think, be shown to be quite possible to keep back the salt water from the inside, by maintaining an almost even pressure on both sides, but giving that of the fresh water the slightest advantage.

By adopting this course for my proposed over-ground water-mains there would be a saving of quite half a mile of piping, whilst, at the same time, the railway, if the gradients would suit, would be shortened by as much, and the proposed simple embankment for the railway would probably cost much less than the intended bridges and railway embankments as surveyed; whilst by my proposed measure we might prove the possibility of shutting off salt water from fresh, and then leaving it to be a matter of time only for the fresh water floods to clear out the salt and

brackish waters from behind, to create a fine fresh-water lake extending to Liverpool, a distance of more than 20 miles.

Before passing on from this subject, I desire to be clearly understood that the above remarks should in no way be considered as an advocacy of the so-called "George's River scheme," as in the least against my gravitation plan; because by my method, certainty of pure supplies in abundance from high elevations and with valuable pressure would be the consequence, as against the risk of obtaining adequate supply of pure waters under what could only be at best a pumping scheme from George's River.

I regretted that there were no members present at our last meeting who represent our present water supply system, and who persistently advocate an extension of the Lachlan and Botany swamps sources of supply. As none of these gentlemen were present at the meeting, and as I observed that they tacitly ignored my gravitation scheme, I hope I may be permitted to make some allusion to their amended and proposed method of extending the supply of water for the city.

Feeling strongly upon this point of our present supply, I should, perhaps, under this opportunity, be wrong in withholding my own expressions on this subject for what they may be worth, and I trust therefore that I may not be considered to be out of order in making the following remarks on the Botany water supply.

Much has lately been said as to the mistaken advocacy of reserving thousands of acres around the present nucleus of a large city, and which is unanswerable; but too little has, I think, been said of the risk of the supply waters failing under severe seasons. I believe that most men of long experience here think that all the exising dams and proposed extension would avail nothing if we were to have even only one such drought of which we have seen many in years long past; neither is it thought that the supposed artesian pressure of water at Botany would exist when once the upper sources of water of the super-incumbent sand drift were exhausted.

Next to the imminent risk of total exhaustion of water comes the other serious objection to an undue prolongation of the Botany supply. This lies in the growing sources of pollution to such waters. This evil is annually becoming greater and greater, and dangerously worse and worse, because no amount of filtration is a guarantee against the pernicious solutions of nitrates, sulphates, and chlorides, which emanate from the dissolution of animal and vegetable, and even from mineral matters from the neighbourhood of dense populations. In our case here this great evil has been proved by Professor Liversidge, having detected the presence of nitrates and nitrites in the Crown-street reservoir waters which are pumped up entirely from Botany.

The importance of an exhaustive consideration of this water question being at present paramount, I ask for the privilege of supporting the above remarks, as bearing upon our present Sydney water supply by quoting from the able work of Johnston, who devoted a most useful life to the study of practical chemistry for the benefit of man. At page 40 of vol. 1 of his book on the "Chemistry of Common Life," he says: "As the solvent power of water enables it to take up many substances from rocks and soils through which it passes, it often happens that in the neighbourhood of dwellings and farm-yards, and especially in towns, the water of wells becomes very impure and even unwholesome to drink. The rains that fall upon the filth that accumulates in towns, wash out the soluble substances it contains, carry them into the soil, and through this, by degrees, into the wells by which the wants of the inhabitants are supplied. This has often been productive of serious and fatal disease. It shows, therefore, the propriety of preventing, as far as possible, the accumulation of refuse, and, where such accumulation is unavoidable, of placing it at the greatest distance from wells which yield water for daily use. And especially it shows the necessity of bringing water from a distance for the supply of large cities."

Up to late years, and even now, the Sydney water supply has been valuable, and is yet a great boon for the city; but by comparing past seasons as known to myself from 1834, and on for twenty-five years since then, it behoves us to be guarded against the delusion of thinking that the wetter experience of the later fifteen or sixteen years will be continued uninterruptedly. The Botany supply has been to us as a nurse's valuable feeding-bottle for the infant city; but it is high time to wean Sydney from such a mode of sustenance, although I would never advocate the actual dismantling of that feeding-bottle, even when another system of supply may come in.

Before closing my remarks in general reply, I would beg to say that objections have been raised to my high gravitation and pressure plan in pipes, on the plea of its expense. Few, if any, other objections that have been raised against my water supply scheme seem to me to be less tenable than this one. By my proposed mode of laying strong wrought-iron pipes on sleepers along the line of transit, a great deal of engineering of levels and excavations would be saved, and to such an extent as to make this method of leading water under pressure nearly, if not quite, as cheap as making open aqueducts through solid sandstone, or pitched aqueducts (paved in cement) there or anywhere else, whilst at the same time this mode of confined conduit of the waters from high elevations render the iron piping to be an engine of enormous force, when properly utilized for its hydraulic power,

as shown by the water delivery and water power notes on the face of my map, and in my late paper, whereby it may be seen that if two pipes of only 24 inches diameter charged at an elevation of 1,062 feet over the sea, and conveying 18,000,000 gallons of water daily to the Waverley and Petersham heights, including 4,000,000 gallons to be sent into Sydney direct under full pressure for fire-mains and engine power, there the hydraulic force that would be available for machinery at those places, and without the necessary loss of any of the pure water for after-consumption, would be equal to no less than 3,184 *h.-p. of incessant action day and night*, and which competent engineers here estimate to be worth no less than £20 per each h.-p. per annum. At this valuation, and if the power was realized to its full extent by capitalists, as is done to a like extent in Freiburg, the income that would be derived from this resource alone would amount to no less than £63,680 per annum, and this sum reckoned as it were at 5 per cent. interest would represent a vested capital for the country of no less than £1,273,600, which would alone, and without reckoning the value of a delivery of 18,000,000 gallons of pure water into Sydney and suburbs, be more than the probable total cost of the whole of my gravitation scheme, completed from one end to the other, with a full supply of water by the double pipes of 24 inches diameter.

Finally, I may venture to say that if the Illawarra railway by the direct route becomes a determined fact, and if adequate labour can be obtained, this project of water supply for Sydney by gravitation could be completed in two years from the time the work would be commenced, after George's River had been rendered crossable by the railway, to facilitate the transport of the iron mains and large quantities of Portland cement.

Discussion.

The Rev. W. Scott understood that Mr. Manning proposed to convey the water by continuous mains from a height of over 1,000 feet; and he asked for information as to the power of resisting the enormous pressure on the pipes. If the pipes were 12 inches in diameter, the pressure at the lower end of the main would be something like 45,000 lbs.

Mr. Manning said that the mains would be a series of strength, according to the altitude of pressure. He had appended to his plan a note to the following effect:—"If two wrought iron or steel mains of only 18 inches diameter, be applied to the high elevation of 1,062 feet at point A, the pressure could be borne with safety, and the velocity of the water delivered would be so great that no less than 4,270,801 gallons with the 850 feet pressure could be delivered daily into a reservoir on the top of the Petersham and Canterbury heights by one pipe, and the highest point

at Waverley, with 750 feet pressure, no less than 4,029,143 gallons daily by the other. In all, these pipes would deliver (by Eitelwein's formula) 8,300,034 gallons daily. These mains would be in three series of strength, according to the altitude of the pressure on the pipes, namely, by boiler-plates of 4-10ths, 6-16ths, and 8-16ths of an inch. In ratio, the application will be as the Nevada Waterworks, where a pipe of 11½ inches diameter and of 5-16ths of an inch bears the enormous pressure of a head of water of no less than 1,750 feet, which is equal to 750 lbs. to the square inch."

Discussion.

The Chairman asked how Mr. Manning would prevent Sydney from being flooded in case one of the pipes burst.

Mr. Manning said there would be stop-valves in every direction, and every here and there along the mains, by which the water could be readily turned off.

The Chairman remarked that he had been over the ground himself, and he must say he never saw a piece of country so well adapted to become the source of a water supply. It was certainly fit for nothing else. The water was as pure as any one could wish to drink.

Dr. Belgrave had looked over the reports of the Water Commission, but saw nothing which would invalidate the assertions of Mr. Manning. It was certainly time something was done to give Sydney an adequate supply of good water; for want of it we were losing the flower of the population. The medical men of Sydney had for some time past been overworked in attending to diseases, the causes of which were attributable to the insanitary condition of the city. He thought it very desirable that the Government should take in hand the development of a new scheme of water supply, whilst money could be borrowed at a reasonable rate. War might break out in Europe at any time, and, if it did, it would be difficult to borrow money. We wanted also a better system of watering the streets of the city, to keep down the dust. He had been in Egypt, but he confessed that he found more blind persons here than in Egypt, in proportion to the population; and the blindness arose principally from the dust. The dust of the city also produced a definite form of consumption, resembling the consumption which the potters of Staffordshire suffered from. He thought the Royal Society was very much indebted to Mr. Manning, and it ought to urge upon the Government the desirabilty of losing no time in inquiring into the feasibility of Mr. Manning's proposals.

The Hon. C. Campbell moved a vote of thanks to Mr. Manning for his able paper and patriotic labours. He was not sufficiently alarmed at the inadequacy of the present supply to think the Government ought at present to incur any large

expenditure in developing another scheme; but he thought, with Mr. Manning, that it was of the utmost importance that the vast watershed referred to by that gentleman should at once be reserved from sale by the Government.

The Hon. R. Owen, in seconding the motion, said he thought no time should be lost by the Government in having the country referred to by Mr. Manning properly surveyed, and Mr. Manning's scheme tested.

[Plans.]

SCIENTIFIC NOTES.

By H. C. Russell, Esq., M.A., Government Astronomer.

[*Read before the Royal Society, 3rd November*, 1875.]

When our Council, last Wednesday, asked me to say something about my recent trip to Europe, I consented with some reluctance, not because I would rather not speak, for I am glad to be able to afford information to the members of the Society, but because I was afraid that I should not be able to interest you while the illustrations of nine-tenths of the facts I have collected are somewhere on the Pacific.

On the last occasion I had the pleasure of saying anything to the members of the Royal Society, it had reference to the transit of Venus, and probably, though most of what transpired while I was in England has already been published here, a few words on that subject may be said now. You are aware that at the time our photos. and drawings of all the phenomena of the transit were exhibited to the members of the Royal Astronomical Society, they were believed to be the best and most complete; so far as I have been able to learn they still hold that position for definition on the edges of the sun and planet, which are the essential points, but they are not so dense in silver as some others which were exhibited afterwards. This is easily explained. Prior to the transit, it was pointed out that to intensify any of the photos. would be to spoil them, for the deposit of silver would take place at the edges as well as in the thickness, and considerable uncertainty would in this way be introduced into the value of the picture; in fact, it was understood that, as the density of the pictures would vary from atmospheric and mechanical causes, the application of an intensifier to bring them up to the mark would make the edges of some creep more than others, and make them very unsatisfactory, if not useless for the purpose of measurement. We, in the Colony, carefully abstained from intensifying any photo. and left them exactly as they were taken; others have departed from this important principle, hence their negatives have more silver than ours; how far this will affect their value remains to be seen when they come under the micrometer. It is to be hoped that they will all be better than is expected, for it is a very general opinion that the times of contact will not prove so satisfactory

as was anticipated. On this point, however, it is perhaps premature to speak. Professor Newcomb, of America, holds the opinion that I know some of my fellow-observers in the Colony will be glad to hear, viz., that external contacts will give quite as good, perhaps better results than internal contacts, an opinion which my own observations and those of several of the New South Wales observers fully bear out.

As it is very important that all the photos. which are to be combined should be measured with the same instrument, and under similar conditions, Sir George Airy has constructed one specially for the purpose. I had the pleasure of seeing it, and I will endeavour in a few words to convey an idea of its form:—First then, we have a strong rectangular casting of brass, about eighteen inches long and seven wide. On this, near one end, is a plate-glass scale seven inches long, and at the other end a convenient table for holding the photograph. Projecting up from this casting are six strong brass pillars, five inches long, and upon them a similar but lighter brass casting, which is on the upper surface formed into a bed, on which the microscope stage slides along. In this stage, and fixed as to their relative distance, are two microscopes, one of which is focused on to the glass scale and the other on to the photo. The stage may be moved rapidly by hand, and has a screw for fine motion. The measurement is made as follows:—Having placed in the negative, its position is adjusted until the line in the microscope becomes a tangent to the limb of the sun, to each limb of the planet, and to the second limb of the sun, by simply sliding the microscope stage along. When this is done, careful readings are taken of the glass scale when the microscope line occupies each one of the tangential positions. The difference between the extremes gives the diameter of the picture, or sun; and from the four readings between the two limbs of the planet and the two limbs of the sun, the centres of the sun and the distance of the centre of the planet from it are obtained. These measures will be repeated till a satisfactory measure is obtained. It will be observed that the Astronomer Royal in this arrangement makes no use of the reference lines on the pictures, but trusts simply to the distance of centres. One uncertainty—that of the perfect reliability of the position of these reference lines—is done away with, but it will be observed that, for this advantage, the gain to be derived from taking the average edge of the whole sun instead of two points in it, which may be enlarged or contracted in some photographs from accidental causes, has to be given up. It is probable, however, that Dr. De la Rue's micrometer will also be used. As I have no drawings of this instrument, which is rather complicated, I may say that in general plan it is similar to the American one, designed by Professor Harkness, but instead of glass scales read by microscopes, it has brass scales read by verniers.

Professor Harkness's micrometer has, in the first place, a tripod like an ordinary theodolite; it has also the vertical axis and the horizontal circle for measuring angles of position. On the top of the vertical axis is a table on which the photo. is placed; and it is rotated under a microscope until the edge of the sun remains bisected by the micrometer line during a whole revolution; from the table on which it rests a microscope projects for reading the circle and getting angles of position. On the same tripod on which this table works a very firm rectangular frame is placed; it rises about 5 inches above the photo. and carries two microscope stages which move exactly at right angles to each other; on each of these are two microscopes, one of which reads the photograph, and the other a glass scale placed by the side of it. Of course, with such a perfect micrometer as this, the position of the planet on the sun may be measured in several ways, and if thought desirable, measures may be taken as in Sir George Airy's. But I believe the intention is, to measure first the angle of position, or the angular distance of the centre of the planet from a vertical line passing through the sun's centre, and then measure its linear distance from that centre.

It will be long before all this is done. Up to the time I left England, August 14, they had not begun the actual work, and at Washington they were in the same stage of progress, *i.e.* making ready preliminaries. In England and America they talk of from two to three years before the work is done.

In the transit circle, the most important of all astronomical instruments, some remarkable changes are now being made. Most, if not all, here present are aware that when graduated circles for astronomical purposes first came into use, and when the graduations had to be made by the repeated and painstaking application of the compasses, which would, I fear, exhaust the patience of a modern artist, quadrants of from 8 to 10 feet radius, and mural circles of 8 to 10 feet diameter, were common; and even when the genius of the elder Simms succeeded in making a dividing engine so perfect that it still stands unrivalled in the world, large circles were still considered a necessity, and made of from 4 to 6 feet diameter. The result of long experience proves that it was not so much in the graduation as in the optical power of the old instruments the fault existed; and now, when the optical power is quadrupled, it is found that not only may the circles be reduced but that actually better results can be obtained from circles only 2 feet in diameter; and these, be it remembered, graduated with the same engine that was used long ago. And so strongly is opinion setting against large circles that the best maker on the Continent refuses to make a circle of more than 2 feet in diameter, even when it is ordered; and Simms, the best maker in England, would rather make them of 2 feet than a larger size.

Another change is that all modern meridian instruments have a circle on each end of the axis—one being fixed, the other free to move when wanted for testing the graduations of the fixed one. Each has its own set of four microscopes, supported not on the stone piers as of old, but on a metal circle attached to the Ys, or supports of the instrument. Graduated circles have always been made as an open framework. At first they were built up of several pieces, circle and radial arms being screwed together. Next, to ensure more equal temperature effects, circles were cast in one piece, but still with open spaces, one arm might therefore be affected by a change of temperature which did not reach the others. Now, in the new transit circle which I had the pleasure of ordering for our Observatory when in England, the circles are for the first time solid, so that such partial effects can no longer take place. Mr. Simms considers that this will give the best results, because it is the form used in the dividing engine with which such splendid results have always been obtained. In most modern transit circles also, errors of from one second to two seconds of arc have been found, and at last traced to a yielding of the tube where it is made fast to the axis, partly owing to weakness, and partly to the excessive weight placed at the ends of the tube. Both these defects have been cured in our new instrument, and I hope it will prove one of the most perfect ever constructed. One other point with regard to the transit instrument. It will be within the memory of some here present that, some years since, my predecessor (Mr. Smalley) read a paper before this Society on "azimuthal changes in the Sydney transit circle," similar to what had been found in several other observatories, and tried to account for this as a result of temperature on the rocks under the Observatory. A similar result had been found at Edinburgh, and the circumstances were such as led the Astronomer Royal for Scotland (Piazzi Smythe) to suspect it was all to be attributed to the effect of the temperature on the stone piers which supported the instrument, even though they were of the same stone, size, and shape. The changes he found were, as in our case, in level as well as in azimuth, that is, the observations showed that at times one pier got longer than the other, and that at other times one or both piers twisted the instrument out of the meridian by leaning over to north or south. To prove it was an effect of temperature, he put a small hand oil-lamp close to the south side of the pier, whilst the telescope was directed on a mark, and at once he saw an effect in azimuth; the pier had expanded on that side, and leaned over to the north. Removing the lamp, he allowed the pier to recover its position, and then applied lamps on both north and south sides of the same pier, and, watching the level, saw the effect of the lamps; for the pier expanded gradually, changing the level of the instrument. One of the first things that

came under my notice on my return was a remarkable confirmation of this discovery. The Surveyor General has erected at the Observatory, for the purpose of connecting two hill stations, in the trigonometrical survey, with Sydney, a most valuable theodolite, made, with all modern accuracy, by Mr. Simms. The instrument stands on a pyramidal stone base about 10 feet high. Very great care was bestowed upon the construction and proportions of this pier, yet when the theodolite was placed upon it and adjusted, an unexpected difficulty presented itself—if the beautiful levels upon it were adjusted with every care, a very short time sufficed to put them wrong again, much to Mr. Surveyor Conder's annoyance. I saw the changes going on, and at first thought the pier and instrument had not settled down to a position of rest; but, while looking to see if this was so, I observed the sun shining on one side of the pier. At once the discovery at the Edinburgh Observatory occurred to me, and upon watching the pier it was found to obey the same law. If the temperature increased on one side that expanded, and *vice versa.* While upon transit circles, or the determination of accurate star positions in the meridian, I may mention a remarkable invention of Father Resphigi, the King's Astronomer at Rome, who showed it to me. Circumstances at his observatory were favourable for this, though very unfavourable for astronomical pursuits in many other respects. His observatory is on the top of the Capitol at Rome, and it is so high that he was able by making holes through various floors to place some mercury 100 feet below a 4-inch transit instrument. Now, of all the tests applied to the adjustment of the transit instrument, none is more satisfactory than that of seeing the image of the lines in the eyepiece reflected from a mercury surface, to prove that the line of sight is vertical. If, then, a star could be seen at the same time, that star's position would be known, free from the uncertainties that worry an astronomer; and owing to the distance of the mercury from the instrument it is possible to see the star transit the wire, and at the same time to see that the vertical adjustment is perfect.

Some most valuable results had been thus obtained, when it was found that even in Rome science had to give way to something more practical. The Government wanted the lower floors for offices, and shut up Father Resphigi's well and his investigation together.

Amidst all the improvements going on in the transit and other instruments, the Equatorial is by no means forgotten, and though I cannot enter into details of mechanical improvements, a few facts about them may be mentioned. When in 1861 Messrs. Chance Brothers exhibited a pair of discs over 25 inches in diameter a wonderful stride had been made, and when after astronomers and Societies had passed them by, Mr. Newall stepped in, and, for the sake of science, bought them, and putting them into

the hands of the best optician then in England, determined to go to any expense to solve the question, Was it possible to make a telescope so large as 25 inches diameter? All credit ought to have been given to him for the spirit which led him to spend £11,000 in so grand and so successful an experiment. Since Cooke made that telescope others have not been idle. Alvan Clarke and Sons, of Boston, have made one of 26 inches for the Washington Observatory, one of 26½ inches for a private citizen of America, and have a flint lens now of 29 inches, which only waits a fellow crown disc to be made up. Grubb, also, of Dublin, has received an order from Vienna for one of 28 inches, and the only thing which hinders the production of these large telescopes is the difficulty of making the glass. Practically there are only two makers—Chance Brothers, of Birmingham; and M. Feil, of Paris. I was anxious to know something about the production of optical glass, and made it my business to call upon both these makers, and I learned something that may be interesting to others. The special proportions of ingredients to make the glass are of course trade secrets, but no secret is or I suppose can be made of the way it is converted into discs for optical purposes. I confess I had the impression that after being made and allowed to anneal for a long time in the pot with the greatest care, it was sawn into horizontal slices presumably of uniform specific gravity, and after careful examination for faults, ground into lenses. No such gentle handling, however, is accorded to it, for after the pot of glass is cool, it is taken out and a good sledge hammer applied to the pot, till it and contents fall into fragments of all shapes and sizes. These are collected and sorted, first by their sizes for special purposes, and then by careful examination as to quality; larger pieces, if they contain any faults, bubbles, sand grains, or pieces of pots adhering, have these at once ground out if possible. If not, each piece is put into a clay mould of the size it will fill, the bottom of the mould is curved roughly to shape the glass, and then both together are put into the oven until the glass is soft enough to be pressed gently into the mould. After this it is carefully annealed. If any faults now appear they are ground out by a small emery wheel and the disc moulded again. I have seen pieces that have been moulded five times over in this way. It is not surprising, then, that many of the discs so made are in a state of abnormal strain, and exhibit the phenomena of polarization so much that they have to be rejected, or again annealed, at the risk of breaking them. Hence the enormous price obtained for such discs of optical glass. M. Feil, of Paris, has the order for two discs for Vienna, to be ground by Mr. Grubb, of Dublin. They are to be 28 inches when finished; and the moulds for them, which M. Feil showed me, are 30 inches in diameter, 2 inches being

allowed for faults at the edge. For the two discs he is to receive £1,000, and has twelve months' time to make them in. It is much to be regretted that some scientific Society, or individual with time and means at command, does not take up the question of progress in the manufacture of large telescope discs. I fear little progress is to be expected while the manufacture continues as it is; and it is not surprising to me that so little has yet been done with large refractors. The large one at Washington is in most able hands, part of the time being devoted to satellites of Saturn, Uranus, and Neptune, for which its great light-collecting power is most valuable. But though great part of the time is devoted to the examination of the physical appearance of planets, &c., little or nothing new has yet been seen; indeed, the new dark line which I discovered last year in the belts of Saturn with the 11½-inch Schroeder telescope at the Observatory, had not been seen with it or indeed with any telescope that I could hear of in Europe. With regard to large reflectors, several experiments are in progress. One at Edinburgh of 2 feet diameter and only 10 feet focus, is said to be a failure, though beautifully made. The foci of the central part and outside ring differ, and of course no sharp definition can be obtained. The other one is the 4-feet silvered glass reflector, projected by M. Foucault, and which he did not live to finish. When I was at the Paris Observatory, early in July, the polishing was finished, and they expected to have it silvered and mounted on its fine equatorial stand by the 1st of August. They were kind enough to set it up for me, and I had the pleasure of seeing a clock face with it, and although the focus is only 28 feet, the definition is very sharp and satisfactory.

As to the possibility of constructing large achromatics with success opticians differ in opinion widely. Some think it impossible to get good definition beyond about 12 inches diameter, simply from the fact that the weight of the glass itself then becomes sufficient to produce in some positions polarization. Others think that the only limit to the size is the difficulty of making the glass.

Clocks, the next requisite for astronomy, are also under investigation, and now that the mechanism is made so perfect that the varying atmospheric pressure can be distinctly traced as a disturbing cause, various devices are being resorted to for its removal. Sir George Airy places the clock below ground with temperature as uniform as possible, and makes the variation in the height of the barometer alter the centre of gravity of the pendulum, so that the clock rate is uniform. So far the result is very satisfactory. Professor Förster, of the Berlin Observatory, shuts the clock up in a glass cylinder, from which a part of the air is withdrawn, so that there is a constant pressure on the ends of it which are ground on. So satisfactory is this method of ensuring uniform

pressure that, after the lapse of ten months, the internal pressure was found to be very slightly *less* than at first, which Professor Förster thinks arises from the deposition of some water vapour into dew. The temperature is kept as uniform as possible by placing the clock between thick walls below the ground, and having double doors at the entrance. In reply to my question, Professor Förster said that, in spite of this uniform pressure and temperature, the time-keeping for long periods was no better than under ordinary conditions, but that he thought for measuring small intervals of time there was a great gain, in fact that the clock-rate did not vary so suddenly. Lord Lindsay, who has, at Dunecht, near Aberdeen, perhaps the most complete observatory in Europe, has constructed a special underground chamber for his clock, besides the correction for pressure. Any possible variation of temperature is to be prevented by a most ingenious contrivance designed by his astronomer, Mr. Gill. Outside the building is a boiler with a constant fire; from this a pipe leads to a coil in the clock room and thence back to the boiler, so that a constant circulation would be kept up; but at one point in the circuit the pipe is bent into a V shape, and at this bend a mercurial thermometer of large size is constructed with such a quantity of mercury that at any required temperature, say 60°, it fills the lower part of the V bend and stops the circulation; if the temperature falls to 59° the mercury contracts and allows the hot water to circulate again.

Probably all these precautions will prove that great faults still exist in the mechanism of clocks. With regard to chronometers, Mr. Hartnup, the director of the Liverpool Observatory (established specially for testing chronometers and making time signals), has made a most important discovery, which, though it does not remove the causes of irregular time-keeping at sea, makes the effect of them a quantity which can be definitely known. I have not time for a full description of what he has done, but will endeavour in as few words as possible to indicate it. It has been customary in testing chronometers to put them in ovens in which the temperature was kept *about* a certain point, say between 60 degrees and 70 degrees, and then change that for another in which a similar variation in temperature was allowed. In this way, though the varying rates between high and low temperatures could be ascertained satisfactorily, yet the law which governs these changes was not indicated until Mr. Hartnup began keeping the chronometers at a definite temperature long enough to ascertain their rates at that point, and then changing it to two others in succession, and at each determining the rate. The temperatures chosen after various experiments are 50 degrees, 75 degrees, and 80 degrees; and he finds that with the rates at these points, he is able to state the law of the variation of rate for each degree of temperature for each chronometer so closely that, in a

voyage from Liverpool to India and back, the time, after corrections are applied, will be very small. It is only necessary to note the temperature regularly during the voyage, and from this and the formula supplied by Mr. Hartnup, the daily rate is at once known. Mr. Hartnup is very anxious to have the discovery tested as widely as possible, and I shall be very glad to show any one interested the result of experiments so far made.

The late Sir Charles Wheatstone has introduced a very curious instrument which he calls a polar clock. One has gone with the Polar Expedition, by which, if the sky is clear, the time of the day may be told within two or three minutes by the polarization of the sky. The instrument is so arranged that the sun's position, and therefore the time of day, is indicated as soon as it is turned sufficiently to remove polarization.

I did not learn much that was new about spectrum analysis. Dr. Vogel, who is appointed to the new Physical Observatory at Berlin (Potsdam), is now engaged making a map of solar lines which will contain three times as many lines as the existing maps. Dr. Vogel is working at the Berlin Observatory, for only the foundations of the Potsdam building are laid, and most of the instruments have yet to be made. Professor Piazzi Smythe thinks that he has discovered some new lines in the spectrum of the atmosphere just before rain. Dr. Huggins, with the beautiful apparatus furnished to him by the Royal Society, was unable to do anything all the time I was in England, simply because the perfection of the apparatus demands such accuracy in the driving clock of the telescope as has never before been obtained; and the clock was away in the maker's hands to see if he could make it do what was wanted, viz., keep the 15-feet telescope directed so steadily to a star that the image in the focus should not vary from its position by the thickness of an ordinary cobweb, or, in other words, that it should keep the same time as the earth on its axis, and not vary a tenth part of a second. Indeed, the great effort now is to improve the spectroscope and the means of using it; the early forms, which increased the power by increasing the number of prisms, always gave a hazy and unsatisfactory definition under high power, owing to the difficulty of grinding the faces of the prisms perfectly flat. And now the effort to improve is taking two directions—first to increase the density of the glass, which M. Feil has done until it is equal to bisulphide of carbon. But here a new difficulty presented itself—such glass tarnishes and turns black in a few days. Opticians, and especially Schroeder, of Hamburg, to get over this difficulty, face the prisms with crown glass, and the large spectroscope made for Potsdam, and which Dr. Vogel is now using for a new map of the solar lines, is of this form; it shows nine lines between the D lines, and is a very fine instrument.

Second—to use as few prisms as possible. Father Secchi, at Rome, thinks he will be able to do very much with one prism and a very long telescope. Grubb, of Dublin, for Lord Lindsay, uses one prism and two halves, and sends the ray eight times through. Hilger, of London, has made one with two prisms for Colonel Campbell, and the ray sent four times through; and the definition is so perfect that nineteen lines have been ruled by the automatic part of this instrument between the D lines. I believe the greatest number ever recorded before was twelve, seen by Dr. Huggins with the great Oxford spectroscope and bisulphide prisms. In a new spectroscope that Hilger has made for the Sydney Observatory there are three prisms of 64° each, so arranged that any power may be obtained from two prisms to eighteen; and the light is sent six times through them. The definition of this instrument is splendid. It was so far finished when I came away that I was able to see the D lines in a small gas flame, perfectly sharp and clear, through eighteen prisms; and the success attending these changes is so great that Mr. Hilger thinks he will be able to get still better results by using one long prism and sending the ray many times through it.

While upon the subject of light, I may perhaps mention one or two other matters. During the time I was in London, M. Cornu, of Paris, exhibited at the Royal Institution and at the Physical Society, his apparatus used in the new determination of the velocity of light by Foucault's method; the principal change is in using telescopes to get the mirrors quickly and exactly into adjustment; and so great was the accuracy attained, that when the apparatus was set upon the lecture table of the Physical Society, and the reflected ray had only twenty feet to travel, the fact that it did take *time* to travel even that short distance was manifest to all who looked, myself amongst the number. As light travels twenty feet in about the fifty millionth part of a second, this small interval of time could be measured by this apparatus. Another curious instrument was exhibited at the same meeting, viz., Mr. Crooke's radiometer, based upon his discovery that any very delicately balanced piece of pith or other substance, placed within a perfect vacuum, begins to move if light is allowed to fall upon it. Having by a number of experiments established the fact of motion under these circumstances, his next care was to make the apparatus in such a form that the motion might be continuous or revolving, and the form adopted is as follows:—A small glass globe, about 2½ inches in diameter, has within it a projecting stem of glass that reaches nearly to the centre; two straws forming a cross, with a needle point through the centre and a little pith disc on each end, is made to balance horizontally with the needle point in the little cup in the end of the glass stem: the whole of the air is then pumped out, so that the globe is very nearly, perhaps quite, a perfect

vacuum; directly a light is brought near it in this condition, the cross at once begins to revolve with a velocity in proportion to the intensity of the light; such a light as that given by burning magnesium makes it spin till the discs look like a solid wheel.

Mr. Crookes thinks they will make perfectly satisfactory measures of the relative intensities of light submitted to them; and hence the name radiometer. Opinion is, of course, divided about this startling instrument. Mr. Crookes, in reply to an attempt made to explain the phenomena by the effect of the heat rays in light, asserted publicly that "he was quite sure that by selecting experiments from the vast number he had made, he could prove or disprove any theory that might be brought forward to explain the phenomena"; and that before forming any theory of the cause or mode of action, he would wait until the general testimony of all experiments left no doubt about the true explanation.

One of the experiments I saw may be mentioned. If a dark source of heat—for instance, a bottle of boiling water—were placed near the radiometer, the arms would not move even if a powerful source of light were brought near them, but upon removing the water bottle, and giving a few seconds to cool the side of the radiometer, the arms at once started off again.

Another very remarkable discovery was exhibited at the meeting of the Royal Society, at which I exhibited our photos. and drawings of the transit of Venus, viz.: Mr. Spottiswoode's artificial aurora. A vacuum tube about 20 inches long was connected with a coil, and a beautiful stratified glow discharge filled it; about the centre of it, on the outside, was an electro-magnet, and directly this was connected with the battery the rings of stratification took on a peculiar rolling sort of screw motion which was very beautiful. It is difficult to get the electrical forces nicely balanced, but the effect while it lasted was very fine, and I need hardly say at once suggested an explanation of the aurora, which it is probable exists under similar conditions. I believe Mr. Spottiswoode is still investigating the matter.

Passing from the science to the practical application of light, there are two or three facts which may be of interest. Dry plate processes of photography are very old, and have gradually acquired a recognised place in the art, though second to the wet plates, with which all the finest results have been obtained. Now, however, Mr. Kennett, of Maddox-street, Regent-street, London, has discovered a process which is better, quicker, and far less trouble to the operator than the well-known wet-plate process. The sensitive material, called by him pellicle, is sold dry and hard, something in appearance like starch. It only requires dissolving in pure water and putting on the plate like ordinary collodion. When dry it is ready for use, and may be used then or six months afterwards. The development also may take place after exposure or at conve-

nience, and is not more trouble than that required for an ordinary wet plate. No more silver baths need then be used to wash out the operator's patience. The process of making the pellicle is of course a secret, but Mr. Kennett told me that he had succeeded in making it so sensitive by removing from the pellicle all the salts formed in the transfer from the neutral to the sensitive state. It has long been known that these salts acted upon the silver deposited by the light, and the sensitiveness of a plate was much increased by exposing it to a weak light before it went into the camera, which produced a light deposit of silver, and in part satisfied the solvent properties of these salts; but no convenient way of removing them was known till now. One curious difficulty met Mr. Kennett. Though ordinarily he had no difficulty in making the pellicle adhere to the plate, yet at times it would peel off every plate coated. Without recounting his experiments in tracing the cause of this, it is enough to say that it was at last found in the state of the atmosphere. If much ozone is present, a slight acidity is produced in the pellicle, and it will not adhere; but the addition of a little soda cures it at once. In Germany another old idea has found some one to work it out to a practical result; and now a picture perfectly sharp and clear all over, and covering an angle of 113°, is taken on a long flat plate, the camera being kept in motion while the glass plate is passed along a slide at the back of it, so that as the camera takes in new points of view, new parts of the sensitive plate are brought forward to receive the picture.

Of the application of photography to facilitate printing, there are several beautiful processes, not new, but only now coming into general use for ordinary illustration. There can I think be no doubt that the Woodbury type produces the most perfect pictures; indeed they are so like the finest silver prints that I doubt if one could be told from the other. The process is wonderfully cheap, even in the hands of the London Company, who have the monopoly; and it is said one man can print without assistance 100 copies per hour of the ordinary carte-de-visite. 100 copies may be had for 10s. One difficulty, however, stands in the way of this process, the enormous pressure required to make the lead printing block. On plates 12 x 15, a pressure of 400 tons is required. The Albert type process is also much used in England and America, but the inventor is in the happy position of Court Photographer generally in Europe, and does not trouble himself about such a small matter as the printing process. The heliotype is, like the Woodbury type, an English invention, but the process and the inventor have been bought by the large publishing house of Osgood & Co., Boston.

Of the heliotype process there are several modifications; thus, if 500 copies are wanted, they are printed from a gelatine surface; if a greater number, up to 2,000, then stone is used;

and if a still larger number, they are printed from zinc. Mr. E. Edwards, the inventor, has also several most interesting processes which work with these. By one he can transfer any writing or drawing done by common black ink to a stone, without the aid of photography, and print off perfect copies by the ordinary litho-printing process. This is used for catalogues, &c., and is, as Mr. Edwards said to me, a dangerous process, for a man's signature can be copied so that he could not tell it from the original himself. By another, any drawing or writing is done upon a glass plate coated with collodion, and this is used to print from. But the stone process is the one with which they do the bulk of their work, and it is so cheap that it can be used to illustrate ordinary business price lists, &c.

Of the sunlight, which does all this for us, we have no satisfactory measures. Whether the sunlight is more this year than it was last no man can say, but many want to know; and attempts have not been wanting to devise something which should record the sun's power. I have only time to mention two of them. The first: took a perfectly round and clear globe of glass, about 4 inches in diameter, and placed it into a hemispherical cup of wood that just fitted it, and exposed it to the sun for one month, and then changed the wooden cup; this was done for each month in the year, and each wooden cup now contains an exact record of the sun's power for that month, but unfortunately it is written in such characters that no one can read them. When they were shown to me I could not but join in the regret expressed, that the results of the experiment could not be determined with any degree of precision; the sun-light concentrated by the glass had burnt away a part of the wood proportioned to its intensity. The other is the invention of Dr. Roscoe, of Owen's College, Manchester, where he showed the whole apparatus to me and asked me to make experiments in Sydney so as to combine them with those in Europe, and I gladly agreed to do this. The test of the sun's power in this case is a piece of sensitive paper carefully prepared, and having a known relation to the sensitiveness of all other pieces used for the same purpose. The paper is in the form of a long tape enclosed in a light tight box, with mechanism that brings a fresh piece of paper under an open half-inch hole in the top of the box whenever a signal is sent from the clock.

Seven signals are sent at the beginning of each hour (or more if desired), so that six separate parts of the paper are exposed to the sun. The first is exposed 1 second, next 2 seconds; 4, 8, 16, and 32 seconds respectively. These are compared afterwards with a coloured scale, and the effect at each interval recorded for comparison with other years and places; the intervals will be so proportioned that the whole of the silver will be deposited in something less than the maximum exposure.

Passing from light to electricity, I must confine what I have to say in as small compass as possible, for I have already much exceeded the limits which should have confined my remarks. Sir William Thompson, of Glasgow, has made a remarkable discovery with regard to the working of electric cables, viz., that by properly proportioning the strength of the current, signals may be got through very much faster than has been supposed to be possible. The maximum rate which he has obtained in an experimental cable of 2,000 miles is 45 words per minute. These are, of course, sent by the automatic sender, and received on a most delicate machine he has contrived, which is capable of writing with excessively weak currents. Some idea of the delicacy of this instrument may be gained from the fact that the pen is a very fine thread of glass, with a capillary tube in it for the ink. This pen is suspended so that the point of it is near but not touching the paper—near enough, however, for capillary attraction to draw the ink on to the paper as the pen moves. To the pen thus hanging freely over the paper a thread is attached, and carried to the light armature that vibrates with the current, and communicates each motion to the pen. The mechanical arrangements were not complete when I saw it; but probably before the end of the year it will be at work, and effect an enormous saving in the expense and trouble of working cables.

I had the pleasure of seeing his beautiful quadrant electrometer, and of securing one for use in Sydney. So perfect is the insulation and arrangement of this instrument now, that once charged it may be kept in an ordinary room, and made to keep up its own charge almost indefinitely. In the application of electricity to lightning and electroplating purposes, perfectly marvellous results are now obtained by Wilde's, and also by Gramme's machines. Wilde's is, I think, much the more powerful of the two, and is preferred by Elkington for depositing metals, because it deposits faster. With one of Wilde's hand machines I melted five inches of No. 19 iron wire with ease; and in his large machine, which he has recently altered, so that the electricity is produced with a much slower rotation of the armature than that required in his earlier machines, I saw five feet of No. 16 iron wire melt away and run like drops of water; and the light yielded by half-inch carbons and 4-horse power engines was magnificent, both in brilliance and steadiness. Gramme's machine also yields a very fine and steady light; but I believe Wilde's will be selected by the Admiralty, for in some recent experiments made for the purpose of testing it at Spithead, it was considered by the officers present impossible for any vessel to come within three miles of a fort armed with one of these lights without being seen, so that she could be fired upon even in the darkest night, rain and fog excepted.

Sir William Thompson's tide indicator is a marvel of ingenuity. In it there are 13 dials or wheels which may be set so that their eccentricity represents the varying effects of 13 of the forces acting upon the tides, by passing a cord over all these wheels, and setting them all in motion so as to vary their effect as the forces vary in their action upon the tides. The time and height of any tide may be known beforehand, subject of course to the unknown effects which may be produced by the wind. In carrying out the wishes of the British Association with regard to the investigation of tides he has obtained many valuable results. A German professor, Dr. Schmick, of Cologne, is working at tidal effects with another object in view, and has written a work which is causing quite a lively discussion on the Continent. Dr. Schmick has collected his data from all possible places, north and south, and amongst them Sydney; and he considers that there is unquestionable proof of an accumulating secular effect upon the waters of the ocean, by which they are during one long period piled up at one pole and submerge the land, and then return and accumulate at the other, and that we are now in the period in which the water is accumulating about the South Pole. Whether the earth is subject to these changes from this or some other cause is not easy to determine. But the question of molecular change in substances on the earth's surface is one that can be investigated much more satisfactorily, and some recent measures taken by Colonel Clarke, of standard bars that had been sent out to India, after comparison, many years since, seem he thinks at least to throw doubt if not wholly to disprove the theory which has been expounded, for no appreciable change was found in these bars, though subject to great heat for many years. With a note of one of the many curious things Sir Charles Wheatstone was kind enough to show me I must close. It had occurred to him that Foucault's pendulum experiment had never been carried out properly, and that it would be much better to *try* if it would go right round than assert that it would because it moved a part of the way. Of course the difficulty was that the pendulum ceased to swing before it had time to make the complete circle, and he set himself to keep it in motion by a force which should act uniformly on it, whichever way it happened to be swinging. This he did by putting under it an electro-magnet, quite round, and having only one pole up; the pendulum in swinging sent a current through this magnet for a moment, and it attracted the pendulum bob, so that if the free pendulum would ever make a circuit by changing its place of oscillation, surely this one would do it; but no, it gradually worked into the plane at right angles to the magnetic meridian, and continued to swing there steadily. This was tried over and over again with the same result; and when I was in that strangely furnished laboratory, Sir Charles Wheatstone was then experimenting to see if this result was brought about by the magnetism, or some want of adjustment in the parts of the apparatus.

The use of aluminium is not making much progress; and now, I believe, it is only made in Paris.

It is used in instruments where extreme lightness is required, as in tubes for telescopes. But the bronze made years ago by Colonel Strange, though as strong as steel, proved so uncertain in castings that it had to be given up, and the instrument which was intended to be all bronze was finished in brass. Messrs. Mathey & Johnson, of Hatton Garden, London, have been trying to alloy it with other metals, and find that a small percentage of nickel adds greatly to its hardness, but does not make it take solder; and to melt up filings seems rather an expensive luxury, for, out of twenty ounces put into the pot, only five of solid metal were obtained. The retail price now is 52s. a pound.

[During the reading of the paper Mr. Russell exhibited interesting diagrams and beautiful photographs.]

EXAMPLES OF PSEUDO-CRYSTALLIZATION.

By Professor Liversidge.

[*Read before the Royal Society, 1st December*, 1875.]

The accompanying illustrations represent some peculiar and interesting examples of fracture, which at first sight might be taken for groups of crystals similar to the common dendritic crystallizations of impure oxide of manganese so often met with in the crevices of rocks, upon fossils, ancient stone implements, and other objects, and to the similar crystallizations of impure copper compounds, often found on paper,* both of which are well known and usually spoken of as *dendrites*, dendritic spots, or by other well-known terms.

The markings here represented, however, have a widely different origin. They were met with upon the lenses of a field-glass, or, to speak more precisely, between the surfaces of the achromatic combinations of the two object-glasses of a field-glass, which had been lost upon the Liverpool Plains, and there left exposed to the sun and weather for a period of five or six years. The long continued exposure to alternate heat and cold had evidently caused the Canada balsam, or other material used for cementing the crown and flint glass portions of the lenses together, to contract and crack along certain lines; the contraction and consequent fractures being due to the loss of turpentine from the balsam by gradual volatilization.

It will be noticed that the groups of cracks in both object-glasses are somewhat similar—the ramifications start from central spots and radiate outwards, and, omitting the minor branches, it will be seen, in most cases that they assume the form of irregular six-rayed stars, somewhat like the hexagonal crystals presented by snow-flakes and ice crystals.

In many of the larger branches, and in some of the larger central spots, there will be noticed curved dark lines, which are probably caused by variations in the thickness of the thin film left between the two surfaces of glass, just as in Newton's experiment. This may be due to the balsam having fractured with a conchoidal surface.

I am indebted to Mr. F. Barton, B.A., for the opportunity to examine this interesting example of what may be termed pseudo-crystallization; and to Mr. J. M. Smith, a student in the University Laboratory, for the very fine photographs which I am able to lay before you. Great difficulty was experienced in

* *Dendritic Spots on Paper.*—A. Liversidge, Jour. Chem. Soc., London, 1872.

taking them, for both the markings and the lenses being transparent, they could only be taken by light reflected at a certain angle. The markings then presented a silvery appearance upon a black background

No. I.

No. II.

Peculiar fracture of the cement between the compound lenses of a field-glass. The resemblance to crystallizations is much more close in the originals than in the photographs and woodcuts.—A.L.

THE MINERALS OF NEW SOUTH WALES.

By Archibald Liversidge, late Scholar of Christ's College, Cambridge, Professor of Mineralogy in the University of Sydney.

[*Read before the Royal Society of N.S.W.*, 9 *December*, 1874.]

The title merely of the following paper was read before the Society on the above date, as the paper is not of a nature suitable for reading in its entirety, but is more suited for reference merely.

The descriptions of the minerals are given almost entirely from specimens which I have either collected myself or which have come under my own personal observation; and the analyses have in all cases been made by myself, except where otherwise stated. It is much to be deplored that no systematic examination of the minerals and rocks of New South Wales has been undertaken similar to that performed in other Colonies. The amount of exact information which has yet been published is surprisingly small.

Some of the localities have been taken from papers published by the Rev. W. B. Clarke, M.A., F.G.S., the late Mr. Stutchbury, who was for some time government geologist, and from some of the reports of the earlier explorers.

Great difficulty was at times found in identifying certain of the localities, from the changes which the names of places have in many cases undergone—numbers of localities I have had to reject altogether on this account, and some uncertain ones probably still remain; but as it is my intention on the first opportunity to bring this little introductory paper out in a more complete form, with, if possible, descriptive figures of the more remarkable specimens, I hope to be able to correct any mistakes which may have crept in, and in a paper of this kind it is almost impossible that some should not occur, although I have done my best to keep the number down to as few as possible.

PART I.

METALLIC MINERALS.

Gold.

Only one true mineral species of gold has up to the present been found in New South Wales, and that is :—

NATIVE GOLD.

Cubical system. Well developed crystals are very rare and are never of large size, seldom exceeding $\frac{1}{4}$-inch in diameter, and the faces are usually more or less cavernous; the most common form are the octohedron and rhombic dodekahedron; single and detached crystals are seldom found, they are usually attached end to end, forming strings, wires, and branching or aborescent forms. A beautiful branching tree like group of large rhombic dodekahedral crystals weighing some 20 oz. was formerly to be seen in the Australian Museum collection, but the specimen has been stolen, so that it is unfortunately lost to science. Occasionally elongated crystals of rhombic dodekahedra are met with, arranged in columnar groups very similar to groups of basaltic columns. As with other minerals, the smaller crystals are usually the most perfect. Filiform, reticulated, and spongy shapes are common; but more so are irregular plates, scales, and strings, which interpenetrate the matrix in every direction. Sometimes, as observed by Mr. C. S. Wilkinson at a mine near Wagga Wagga, the plates are so exceedingly thin that they form mere films like gold-leaf, and in this particular instance the films run both between and across the laminæ of the red-coloured slate in which they occur. Then again, gold occurs in New South Wales, as elsewhere, so finely divided and equally diffused throughout the matrix as to be invisible even by the aid of a lens.

As alluvial gold it occurs in more or less rounded and water-worn flattened grains, scales, and pebbles or nuggets. The largest nuggets discovered in Australia have been found in Victoria, none at all to compare with them in size have been in New South Wales.

EXAMPLES OF NEW SOUTH WALES NUGGETS.

No. 1. Found in July, 1851, by a native boy, amongst a heap of quartz, at Meroo Creek or Louisa Creek, River Turon, 53 miles

from Bathurst, and 29 miles from Mudgee, New South Wales. It was in three pieces when discovered, though generally considered as one mass. The aboriginal who discovered these blocks "observed a speck of some glittering substance upon the surface of a block of the quartz, upon which he applied his tomahawk, and broke off a portion." One of the pieces weighed 70 lbs. avoir., and gave 60 lbs. troy of gold; the gross weight of the other two about 60 lbs. each. These three pieces, weighing $1\frac{3}{4}$ cwt., contained 106 lbs. troy of gold, and about 1 cwt. of quartz. In the same year another nugget, weight 30 lbs. 6 ozs., was discovered in clay, 24 yards from the large pieces; and in the following year, also near to No. 4, there were found two nuggets, weighing 157 ozs. and 71 ozs.

Gross weight (troy), 106 lbs.; 1,272 ozs.

No. 2. A model of what is said to be the first large nugget found in New South Wales is to be seen in the Australian Museum, Sydney. Found in Ophir Creek.

No. 3. A nugget weighing 26 ozs. was found at Bingera in 1852.

No. 4. Found by a party of four, on 1st November, 1858, at Burrandong, near Orange, New South Wales, at a depth of 35 ft.; when pounded with a hammer it yielded 120 lbs. of gold, for which £5,000 were offered. Melted at the Sydney Mint, when it weighed 1,286 ozs. 8 dwts.; after melting, 1,182 ozs. 7 dwts.; loss, 8 per cent.; fineness, 87·4 per cent.; the standard weight of gold being 1,127 ozs. 6 dwts. Value, £4,389 8s. 10d. The gold was mixed with quartz and sulphide of iron (mundic). Assay, 87·40 per cent. gold = 20 car. $3\frac{7}{8}$ car. grs.

Gross weight (troy), 107 lbs. 2 ozs. 8 dwts.; 1,286 ozs. 8 dwts.

No. 5. Found at Kiandra, Snowy River, New South Wales, October, 1860.

Gross weight (troy), 33 lbs. 4 ozs.; 400 ozs.

No. 6. "The Brenan Nugget." Found in Meroo Creek, Turon River, New South Wales, embedded in clay; measures 21 inches in circumference. It was found 24 yards from No. 1. Sold in Sydney, 1851, for £1,156.

Gross weight (troy), 30 lbs. 6 ozs.; 364 ozs. 11 dwts.

No. 7. Found at New Chum Hill, Kiandra, Snowy River, New South Wales, July, 1861.

Gross weight (troy), 16 lbs. 8 ozs.; 200 ozs.

No. 8. Found at Kiandra, Snowy River, New South Wales, March, 1860.

Gross weight (troy), 13 lbs. 4 ozs.; 160 ozs.

No. 9. Found, in 1852, at Meroo Creek, Turon River, New South Wales, close to No. 1. This was called "The King of the waterworn Nuggets."
Gross weight (troy), 13 lbs. 1 oz.; 157 ozs.

No. 10. Found in 1860, at the Tooloom Diggings, New South Wales; nearly solid gold.
Gross weight (troy), 11 lbs. 8 ozs.; 140 ozs.

No. 11. Found at Kiandra, Snowy River, New South Wales, March, 1860.
Gross weight (troy), 7 lbs. 9 ozs. 18 dwts.; 93 ozs. 18 dwts.

No. 12. Found in 1852, at Louisa Creek, New South Wales; a solid lump of gold.
Gross weight (troy), 6 lbs. 10 ozs.; 82 ozs.

No. 13. Found by two boys, in July, 1861, at Gundagai (new diggings), New South Wales.
Gross weight (troy), 5 lbs. 4 ozs. 7 dwts.; 64 ozs. 7 dwts.

No. 14. Found in 1857, at Louisa Creek, New South Wales; gold and crystallized quartz.
Gross weight (troy), 4 lbs. 2 ozs.; 50 ozs.

No. 15. Found at New Chum Hill, Kiandra, New South Wales, in July, 1861.
Gross weight (troy), 3 lbs. 6 ozs.; 42 ozs.

No. 16. Found at Summer Hill Creek, New South Wales. The earliest nugget found in New South Wales after the gold discovery there by Hargraves. 13th May, 1851.
Gross weight (troy), 1 lb. 1 oz.; 13 ozs.

No. 17. A nugget weighing 22 ozs. 18 dwts. 12 grains was found recently on "M'Guiggan's Lead," about 9 miles from Parkes; the metal was of dark colour and free from gangue.

No. 18. A nugget weighing 19 ozs. 12 dwts. was found early in 1876, at the "Wapping Butcher" Mine, near Parkes.

For the accounts of Nos. 1 and Nos. 4 to 16 I am indebted to Mr. Brough Smyth's *Gold Fields and Mineral Districts of Victoria.*

In colour most of the New South Gold is usually of fairly deep yellow, being rather lighter than Victorian and not so light as much of the Southern Queensland gold, but occasionally specimens of very pale and of very dark gold are met with. The quantity of silver present greatly affects the colour of the metal.

In specific gravity it varies considerably, the mean being about 17·5.

A specimen of Braidwood gold had a specific gravity of 18·28.

Composition.—No specimens of actually pure gold have been met with. There is always more or less silver present, and usually traces of copper, iron, and other metals.

PER CENTAGE of silver, copper, and iron in New South Wales Gold. Determinations made at the Sydney Mint, December, 1854.

Gold Field.	Mean of No. of specimens.	Silver.	Copper and Iron.
Tambaroora.........	14	4·735 to 7·64	Trace to ·125
Turon	8	4·29 to 8·37	,, ·13
Meroo	5	3·86 to 5·005	,, ·105
Mookerawa	1	5·69	,, ·03
Ophir	1	5·93	Other metals ·01
Adelong	5	5·115 to 6·665	,, ·015 to ·13
Araluen, Major's Creek	2	5·05 to 6·49	
Araluen, Bell's Paddock	1	10·345	
Bingera, nugget 4 oz. 3dwts.	1	12·525	
Hanging Rock, Oakenville Creek	1	6·295	
Hanging Rock, Cordillera Gold Company, Peel River	1	9·325	
Rocky River	1	5·63	

From the above average the average value was 80/6 per oz., the value of the standard oz. being 77/10½d. For the materials of the above table I am indebted to Dr. Smith.

TABLE showing the proportion of gold and silver in characteristic samples of gold dust, from various localities in New South Wales, after melting. By F. B. Miller, F.C.S., late Assayer in Sydney Branch of the Royal Mint.

Locality.	Gold in 1,000 parts.	Silver in 1,000 parts.
NORTHERN.		
Boonoo Boonoo	854 to 659	337 to 298
Fairfield	872	121
Timbarra	708 to 898	280 to 97
Peel River	929	67
Rocky River	934 to 962	61 to 33
Nundle	923 to 937	66 to 63
WESTERN.		
Bathurst	827 to 903	164 to 92
Sofala	929 to 933	66 to 63
Tuena	943	54
Ophir	915	82
Tambaroora	943 to 954	54 to 42
Turon	918 to 928	78 to 68
Hargraves	915	83
Windeyer	946 to 959	53 to 37
SOUTHERN.		
Burrangong	948	48
Adelong	946 to 951	52 to 45
Braidwood	928 to 934	67 to 62
Emu Creek	971	27
Delegate	971	27
Nerrigundah	983	15

SAMPLES OF GOLD characteristic of the Gold Fields of New South Wales, exhibited by the Mining Department, and assayed at the Royal Mint, Sydney. From the New South Wales Official Catalogue, Philadelphia Exhibition, 1876.

Locality.	Description of Gold.	Weight of Sample.	Loss in melting per cent.	Gold and Silver in 1,000 parts, after melting.		Value per oz., after melting, at £3 17s. 10½d., Standard.		
WESTERN DISTRICT.		Ozs.		Gold.	Silver.	£	s.	d.
Sofala	In fine scales, and coarse plates and grains	2·50	1·54	923·0	72	3	18	9½
Bathurst	Fine scales and coarse grains, with some spongy and stringy	2·00	2·00	923·5	71	3	18	10
,,	Fine scales, plates, and coarse grains	2·00	1·47	918·0	76	3	18	4½
Hargraves	Fine dust and coarse grains	2·00	1·23	920·5	70	3	18	6½
,,	Scaly with some grains	2·00	1·15	961·0	33	4	1	9½
Tambaroora	Fine and coarse scaly and grains	2·00	1·31	940·0	54	4	0	1
,,	Fine scales and grains	2·00	1·55	943·5	50	4	0	5
,,	Reef gold ; reticuled	2·00	2·77	944·5	51	4	0	6
,,	Coarse waterworn grains or nuggets	2·00	2·00	935·5	54	3	19	8½
Hill End	Fine dust and coarse grains	2·00	2·47	945·5	47	4	0	7
,,	Scaly, with coarse spongy grains	2·53	1·41	945·5	50	4	0	7
,,	Fine scales and coarse crystaline gold	2·00	2·18	947·0	47	4	0	8½
,,	Scaly and coarse filiform gold	2·00	1·97	942·5	49	4	0	4
Mudgee	Fine scales and coarse grains	2·50	1·93	941·0	56	4	0	2½
,,	Coarse grains with some scales	2·00	2·04	926·0	68	3	19	0
,,	Fine and coarse scales	2·00	1·77	937·0	58	3	19	10½
Gulgong	Coarse spongy grains and some scales	2·00	1·78	938·0	58	3	19	11½
,,	Dust and coarse scales	2·00	1·78	916·5	79	3	18	3
,,	Coarse pieces—filiform and spongy	2·00	1·78	925·0	70	3	18	11
,,	Scaly, with some grains	2·00	1·59	946·0	48	4	0	7½
Carcoar	Fine scales, very porous. with some magnetic iron	2·00	10·92	878·0	119	3	15	2
,,	Fine and coarse filiform gold of a dark colour	2·00	2·94	960·0	36	4	1	8½
Orange	Scaly	2·00	2·67	943·0	51	4	0	4½
,,	Fine dust—"gunpowder gold"	2·00	2·53	930·5	62	3	19	4
Stony Creek	Scaly	2·00	1·56	942·0	54	4	0	3½

SAMPLES OF GOLD—*continued.*

Locality.	Description of Gold.	Weight of Sample.	Loss in melting per cent	Gold and Silver in 1,000 parts, after melting.		Value per oz., after melting, at £3 17s. 10½d., Standard.		
		Ozs.		Gold.	Silver.	£	s.	d.
SOUTHERN DISTRICT.								
Braidwood	Plates and fine scaly	2·00	1·79	959·0	34	4	1	7½
Araluen	Fine dust—"gunpowder gold"	2·00	2·19	951·5	42	4	1	0½
Adelong	Fine scaly and coarse filiform	2·00	2·63	944·0	52	4	0	5½
"	Scaly...........	2·00	1·27	941·0	53	4	0	2
"	Coarse filiform with some scaly	2·50	1·69	946·0	50	4	0	7½
Tumut...........	Fine and coarse, with some very spongy	2·00	6·28	927·5	70	3	19	1½
Young...........	Scaly dust gold	2·00	2·39	957·0	36	4	1	5½
"	Fine dust—"gunpowder gold"	2·00	1·52	943·0	49	4	0	4½
Nerrigundah	Strings, scales, and plates	2·50	1·64	980·5	15	4	3	4½
Kiandra	Scales and plates with some grains and threads	2·00	3·15	927·0	63	3	19	1
Goulburn	Coarse grains and reticulated	2·00	6·87	975·0	22	4	2	11½
Bombala	Very five scaly dust—"gunpowder gold"	2·00	2·63	963·0	34	4	1	11½
Cooma...........	Filiform crystaline and some scaly...........	2·00	3·17	938·0	56	3	19	11½
"	" "	2·00	4·22	924·0	70	3	18	10
NORTHERN DISTRICT.								
Nundle	Fine scaly and coarse filiform	2·00	3·33	919·5	73	3	18	6
"	Scales, plates, and coarse filiform ; of a brownish colour	2·00	3·28	902·5	90	3	17	1½
Tamworth	Spongy, filiform, and crystaline, some with a little quartz attached.	2·00	3·28	912·0	83	3	17	10½
"	" " " "	2·00	3·31	914·0	80	3	18	0½
"	Fine dust and shotty grains...........	2·00	3.31	899·5	93	3	18	10½
Armidale	Scales with some threads...........	2·00	3·30	948·0	44	4	0	9
"	Fine scales	2·00	1·91	888·5	105	3	16	0

The average fineness of Victorian gold is about 23 carats, that is to say, it contains about 96 per cent. gold and $3\frac{1}{2}$ per cent. of silver, with about $\frac{1}{2}$ per cent. of other metals. Further north, in New South Wales, the average fineness is 22 carats $1\frac{7}{8}$ grains, or $93\frac{1}{2}$ per cent. gold and 6 per cent. silver. Still further north, in Queensland, the average fineness is but little more than 21 carats, or 87·25 per cent. gold, 12 per cent. silver. Maryborough gold only contains 85 per cent. gold and as much as 14 per cent. silver. (*F. B. Miller, F.C.S. Trans. Roy. Soc., N.S.W.*, 1870.)

The Palmer gold, from Northern Queensland, is much richer than any of the specimens from Queensland referred to above.

Vein gold.—The greater portion of the gold found *in situ* in New South Wales occurs in quartz veins running through the older and metamorphic rocks. It is also said to occur under similar circumstances in true igneous rocks. Calcite is occasionally the vein-stuff.

The rocks in which auriferous veins are most commonly met with are the various argillaceous slates, and chloritic and talcose schists; also in granite, as at Braidwood and Bowenfells, porphyries, and other similar metamorphic rocks; in Eisenkiesel, at Carcoar. The walls and "country" of such veins are also usually auriferous to greater or less distances.

As examples of the richness of portions of gold veins, the following may be cited:—A telegram from Hill End, on February 1st, 1873, stated that at Beyers & Holtermann's mine 100 cwt. of gold had been raised in 200 cwt. of stuff. From the same mine a slab of vein-stuff and gold weighing $6\frac{1}{2}$ cwt. was exhibited which was estimated to contain about 2 cwt. of gold. Many other similarly rich blocks were also shown.

The Mint returns for the gold from 415 tons of vein-stuff from this mine were 16,279·63 ozs., value £63,234 12s.

Krohmann's Company, also at Hill End, raised 436 tons 9 cwt. of stuff, for which the mine returns were 24,079 ozs. 8 dwts. of gold, value £93,616 11s. 9d.

Gold reefs in New South Wales have not yet been worked to any great depth. At Adelong they are getting good stone from a depth of 530 feet.

Associations.—The most common minerals which are found with vein gold are iron pyrites, which is never quite free from, and is sometimes exceedingly rich in gold; iron oxide, which is for the most part derived from the decomposition of various pyrites; mispickle, in calcite, as at Lucknow, where the mispickle contains in parts over 200 ozs. of gold per ton; with mispickle at Carcoar, and at Moruya with silver sulphides also; with pyrrhotine and calcite, as at Hawkin's Hill; with galena, zinc, blende, magnetite, molybdenite, chlorite, talc, asbestos, steatite; cuprite, malachite,

and other copper ores, notably in the Wellington and Adelong districts; it is reported with tin in the cliffs at Eden, and with native arsenic at Solferino.

In alluvial deposits gold is associated in New South Wales with a very large number of minerals; and it is remarkable that certain of them such as platinum, osmo-iridium, sapphire, ruby, oriental emerald, and diamond, have not yet been found *in situ.* Amongst the others we have tinstone, titaniferous iron, magnetic iron, chromic iron, brookite, rutile, anatase, emerald, beryl, topaz, zircon, hyacinth, spinelle, garnet, red and brown hæmatite, pyrites, binoxide of manganese, galena, blende, tourmaline, magnesite, and many more of less value.

The alluvial deposits are of various ages, but none of them probably are older than late Tertiary age, and are often deeply buried by overflows of igneous rocks.

Gold is found in small quantities in the tin-drifts of New England, especialy in the older drifts, conglomerates or "cements" as they are termed by the miners.

The Rev. W. B. Clarke mentions that gold is found at the mouth of the Richmond River distributed in the sand and covering pebbles on the sea beach—a similar distribution is found in the sand of Shell Harbour. Other spots give similar indications, and some specimens of gold were brought up from the sea-bottom by the sounding apparatus of H.M.S. "Herald" off Port Macquarie.

Distribution.—From the fact that gold is so widely scattered over nearly the whole of New South Wales, it would be almost an endless task to attempt to enumerate the names of all the localities at which it has been found, it must therefore suffice to refer you to the names of the principal gold fields, already cited in the tables which show the proportion of silver contained by gold from various parts of the Colony, and to the mineral map published by the Government, which roughly shows the approximate area of the various gold fields.

Amount.—The total quantity of gold as recorded in the Government returns from 1851 to 1874 was 8,205,232.598 ozs., and the value £30,536,246 10s. 6d. A model in the form of a huge parallelopipedon, measuring 6 ft. 6 inches square in the base and having a height of 11·1 feet, representing this amount of gold, is now at the Centennial Exhibition in Philadelphia,—the calculation for the above dimensions being based on the assumption that the average specific gravity of the gold was 17·5.

The Discovery of Gold.—It is beyond my province to express any opinion upon the long disputed question as to who was the original discoverer of gold in Australia; but it may not be out of place to quote certain statements which have been made from time to time, so that each may judge for himself.

The *Evening News* of Sydney for 7th August, 1875, contains the following statement with respect to the original discovery of gold :—" We are in a position to show that gold was discovered, and we believe officially reported to the Government, upwards of fifty-two years ago, viz., on the 16th February, 1823. On that date, Mr. Assistant-Surveyor James M'Brian discovered the precious metal at a spot on the Fish River, about midway between O'Connell Plains and Diamond Swamp, a little to the north of the old Bathurst Road, and about 15 miles east of Bathurst. We have now before us an extract from Mr. M'Brian's field book, which book is preserved in the Surveyor General's Office. It reads as follows :—' February 16, 1823. At 81·50 to river, and marked gum-tree. At this place I found numerous particles of gold in the sand and in the hills convenient to the river.' It is possible but hardly probable that other persons may have discovered gold before that date, and that owing to the then peculiar social condition of the Colony, arising from the presence of a large prison population, it was thought best to suppress the knowledge of the fact."

It is stated that Count Strzelecki found gold, associated with pyrites, in 1839, in the Vale of Clwydd.

With reference to the most important part which the Rev. W. B. Clarke played in the discovery of gold in Australia, I cannot do better than quote the words of one of England's most eminent geologists.

Professor Geikie, in his "Life of Murchison," says :—" Count Strzelecki appears to have been the first to ascertain the actual existence of gold in Australia ; but, at the request of the Colonial authorities, the discovery was closely kept secret. The first explorer who proclaimed the probable auriferous veins of Australia on true scientific grounds, that is, by obtaining gold *in situ* and tracing the parent rocks through the country, was the Rev. W. B. Clarke, M.A., F.G.S., who originally a clergyman in England has spent a long and laborious life in working out the geological structure of his adopted country, New South Wales. He found gold in 1841, and exhibited it to numerous members of the Legislature, declaring at the same time his belief in its abundance. While therefore geologists in Europe were guessing, he, having actually found the precious metal, was tracing its occurrence far and near on the ground."

In 1844, Sir Rod. Murchison pointed out the singularity of the Blue Mountain Chain of Australia (the Cordillera) to that of the Ural, and predicted the occurrence of gold ; this seems to have turned out a happy guess, but it cannot be wholly considered as a scientific declaration. His prognostications, 1844–6–7 (appear) however, to have been the first published.

On June 23rd, 1875, some articles and letters referring to the discovery of gold appeared in the *Parkes Gazette*, in which it is stated that Mr. John Phillips announced the discovery of gold in 1847. A letter, dated from Jermyn-street, 16th July, 1855, from Sir Rod. Murchison to Sir Chas. Hotham, is cited, which states that "Mr. Phillips is the person who first announced to me that he had detected it (gold) in your government (1847). I so stated the fact in my letter of 1848 to the Colonial Secretary, Lord Grey, when I urged upon H. M. Government to take the initiative in developing the auriferous resources of the region."

To Mr. Hargraves in 1851 was reserved the satisfaction of showing that gold existed in great quantities in various parts of the Colony and how it could be readily obtained from alluvial deposits by means of the cradle.

Silver.

Native Silver.

Native silver does not appear to have been found *in situ* in New South Wales.

The Rev. W. B. Clarke mentions in his "Southern Gold Fields," that silver has been met with in the Southern Districts in two or three places in the form of small fragments and arborescent crystals. The same author mentions finding a thin plate of flexible silver having a sp. gr. of 10.

Strzelecki found traces of silver in the western country in 1839.

Silver glance.

Chem. comp.: Sulphide of silver = Ag_2S. Silver, 87·1; S, 12·9 = 100. Cubical system.

This ore has been found with iron pyrites in quartz, also in limestone on the Clarence River, and on the Manning River. At two or three places near Bathurst, at Copper Hill on the western side, and at Brownlea; on the Page and Isis Rivers; at Brunaby Creek, county Argyle; at Broulee, Moruya, with cobalt, zinc, and iron; Teesdale, Co. Bathurst; Queanbeyan River, Burra Creek, Yass River; Buckinbah; Tacking Point, Co. Macquarie; Borrowa Creek; Crookwell River; with gold, lead, and zinc at Gulgong; with carbonate of lead at Peelwood; with galena and iron pyrites at Shellmalleer; on the Molonglo River, near junction with the Murrumbidgee, and at junction of Murrumbidgee Creek with Mountain Creek. In nearly all cases the silver sulphide occurs mixed more or less intimately with galena, so that properly it should usually be termed argentiferous galena.

ANTIMONIAL SILVER ORE.

Containing arsenic, at Moruya. (See specimen in the Australian Museum.)

Platinum.

NATIVE PLATINUM.

Reported to occur with gold in the Shoalhaven River, and in the Ophir gold district—in the form of small grains, Bendemeer.

Osmium Iridium.

OSMO-IRIDIUM.

This compound of osmium and iridium is very commonly met with in the auriferous and other drifts of New South Wales in the form of minute grains and scales.

I have observed it in the gem-sand at Bingera, Mudgee, Bathurst, and other places.

Its presence in alluvial gold is occasionally a source of trouble at the Mint, for minute grains are often mechanically enclosed by the gold after melting, which by their hardness speedily destroy the dies during the operation of coining.

Mercury.

NATIVE MERBURY.

In the Mookerawa Creek and in Great Waterhole at Ophir, mentioned by Stutchbury, and he states that mercury had never been used on that creek.

CINNABAR.

Chemical composition: Mercury, sulphide = HgS. Found on the Cudgegong River in an argillaceous matrix, and in alluvial deposits associated with gold, gems, and other similarly occurring minerals, in the form of small rounded masses of a brilliant red colour. Reported to occur also at Moruya.

Copper.

NATIVE COPPER.

Cubical system. Crystallized native copper is by no means rare, but large and well developed crystals as elsewhere are uncommon. It is met with massive, in plates, threads, wires, and arborescent forms, the latter being usually built up of elongated rhombic dodekahedra.

I have been unable to find any analysis of New South Wales native copper, but it probably contains the usual small quantities of silver, lead, bismuth, and other metals.

In nearly all cases it is found in association with cuprite, malachite, and other oxidized copper ores, as at Carcoar, the Canobolas, Wellington, Mitchell's Creek, Bathurst, Pink's Creek, Bell River, Peel River, Manilla, Bingera, Cobar. It occurs in smaragdite on Molong Creek, at Peelwood with lead ores. The late Mr. Stutchbury reports that at Kelloshiels the well-water was found to be so impregnated with copper as to be unfit for domestic purposes.

Cuprite.

Chem. comp.: Copper suboxide = Cu_2O. Copper, 88·8 oxygen, 11·2 = 100.

Usually found massive, but occasionally well crystallized, in cubes and octohedra, which, however, are seldom more than ¼ inch in diameter.

Chalcotrichite, or Plush Copper: The variety crystallized in capillary crystals, met with at the Coombing Mine near Carcoar. The best crystals which I have seen have come from the Cobar Mine.

This mineral is usually associated with the other oxidized copper ores, such as malachite and chessylite.

It is abundant at Cobar, both massive and crystallized; Clarence River, Cowra, Bathurst district, Mitchell's Creek, Wiseman's Creek, Carcoar, Icely, Burrowa, Molong; Manilla, with grey sulphide or redruthite; Bungonia, Yass; Peelwood, with tenorite; Bingera.

Tenorite.—Melaconite.

Or Black Oxide.—Chem. comp.: Copper oxide = CuO. Copper, 79·85; oxygen, 20·15 = 100.

Usually in the form of a black powder, massive, or sporadic, *i.e.*, disseminated in nests. Usually found associated with other oxidized copper ores, as at Carcoar, Wellington, Icely, Peelwood, Burrowa.

Malachite.

Green Carbonate of Copper.—Chem. composition: Hydrous Copper Carbonate = $Cu_2CO_3 + H_2O$. CuO, 71·9; carbonic acid, 19·9; water, 8·2 = 100. Metallic copper, 57·5.

Oblique system. Colour from pale emerald to deep green. Occurs massive, also mammillated and botryoidal with fibrous concentric structure, the various layers often possessing different shades of colour and forming a most beautiful and valuable stone for ornamental and inlaying purposes. Crystals are occasionally met with, and sometimes of large size; those from the Cobar Mines are particularly beautiful. The silky lustre is often very remarkable, the capillary crystals sometimes being several inches long.

It is found in most of the surface workings of New South Wales copper mines, as in the Bathurst district with chlorite, vitreous, yellow, and other copper ores; at Cambalong earthy and fibrous malachite is associated with barytes or heavy spar, and with yellow and peacock ore; at Cobar, with steatite; Mitchell's Creek, Wellington, mixed with other surface ores, and often containing large quantities of gold and silver; Reedy Creek, Icely, Peelwood, Yass, Bingera, and other places.

Chessylite.

Azurite, or Blue carbonate of copper.

Chem. comp.: Hydrous copper carbonate. $2\,CuCO_3 + CuH_2O_2$. Copper oxide, 69·2; carbonic acid, 25·6; water, 5·2 = 100. Oblique system. Colour from azure to indigo blue, translucent to opaque.

Found massive and crystallized. The best specimens of the latter come from the Cobar Mines. They often assume a radiated concretionary form, with the terminal planes of the crystals studding the surface of the balls in the form of small projections. These concretions vary from almost imperceptible points up to balls several inches in diameter, and as they often occur diffused through a pale grey or green coloured steatitic clay they present an extremely pretty appearance; at other times the crystals are set off by a dazzling white felspathic clay. Well developed crystals are also found lining vuggy cavities.

At Cobar chessylite is associated with atacamite in addition to the other more commonly occurring ores.

At Woolgarloo chessylite occurs with native copper, cuprite, and malachite in pink and white fluor spar. This mixture has at times a very pretty effect, from the manner in which the copper minerals are diffused through the cracks and reticulating cavities in the fluor spar. Something of the same sort of thing is to be seen in the fluor spar from South Wiseman's Creek.

Amongst other localities for chessylite are Inverell, in quartz veins; Bathurst, Peelwood, Icely, and Ophir.

Atacamite.

Chem. composition: Hydrous oxychloride copper $= 3CuH_2O_2 + CuCl$. Copper oxide, 53·6; copper chloride, 30·2; water, 16·2 = 100. Rhombic system. Dark green in colour.

Occurs in the Cobar and Cowra copper mines.

Chryscolla.

Chemical composition: Hydrous copper silicate $= CuSiO_3 + 2H_2O$. Copper oxide, 45·3; silica, 34·2; water, 20·5 = 100. Amorphous. In colour, dark-green.

Reported to occur in a matrix of semi-opal at the Coombing Copper Mine, 2 miles from Carcoar. Also occurs at Cobar.

Phosphocalcite.

Pseudomalachite.—Chem. Comp: Hydrous copper phosphate $= Cu_5P_2O_{10} + 3H_2O$. Copper oxide, 67·0; phosphoric acid, 23·9; water, 9·1 = 100. Rhombic system. Colour, dark-green.

Coombing Copper Mine.

Arseniate of Copper.

Mentioned as occurring in a quartz vein on the Cox River, but it is not stated whether the mineral was condurrite, olivenite, or one of the other arseniates.

The next group of copper ores comprises the various Sulphur Compounds of Copper.

Redruthite.

Erubescite, vitreous copper ore, copper glance.

Chem. comp: Copper disulphide $= Cu_2S$. Copper, 79·8; sulphur, 20·2 = 100. Rhombic system.

I have only seen this mineral in the massive state, but it is found crystallized in South Australia. It is of a lead-grey colour, soft, and leaves a shining streak.

Found at Cobar; Manilla waters, near Bowral; near the Wellington Caves, with blue and green carbonates in a quartzose veinstuff; also at Wellbank, near Wellington; at Cardiangullong Creek, with iron pyrites; at Bathurst, Kroombit, Icely, Carcoar.

Bornite.

Purple ore, Buntkupfererz.

Chem. comp: $= (Cu_2\ Fe)\ S_2$. Varies considerably.

Copper, 56 to 70; iron, 6 to 17; sulphur, 21 to 26.

Cubical system; colour, copper red, purple to brown; massive; fracture, even to small conchoidal; streak blackish-grey, shining.

Found at Cobar; Bingera; Wellbank, Wellington District.

Fahlerz.

Grey Copper Ore. Tetrahedrite.

Chem. comp.: $4CuS + Sb_2S_3$ but variable.

Part of the copper often replaced by iron, zinc, silver (up to 30 per cent.), mercury, or cobalt; and the antimony partly replaced by arsenic and occasionally bismuth.

Cubical system, usually in tetrahedral forms—hence one of its synonyms; colour, grey; soft, cuts with shining streak.

Occurs on the west side of Copper Hill, near Molong.

CHALCOPYRITES.

Copper pyrites. Chem. Comp.: Copper-iron sulphide $Cu_2 S, Fe_2 S_3$. Copper, 34·6; iron, 30·5; sulphur 34·9 = 100. Tetragonal system; hemihedral forms. A very abundant ore.

Usually occurs massive; occasionally crystals are met with, but they are generally but imperfectly developed. Colour, usually brass yellow. Blister ore is more of a bronze colour, and occurs in mammillated and botryoidal forms. The tarnished variety of copper pyrites, known as peacock ore from the splendid colours which it acquires, is very common.

It occurs in nearly all the metalliferous districts in the Colony: at Cobar, Bingera, Elsmore, Clarence, Wiseman's Creek; Wellington and Bathurst districts, with zinc blende, steatite, quartz, and asbestos; Wallabadah, Carcoar, Cargo, Ophir, Peelwood, Tuena, Bungonia; at Currowang, on the Shoalhaven; Adelong, with gold; at Lob's Hole on the Tumut; Kiandra.

Bell-metal Ore—Cobar.

DOMEYKITE.

Arsenical Copper Sulphide. Chem. Comp.: Copper arsenide, Cu_3As. Copper, 71·7; arsenic, 38·3 = 100.

Amorphous. Occurs in the Bathurst District with yellow sulphide of copper.

ANTIMONIAL COPPER ORE.

Said to occur at Eden, Twofold Bay.

Dioptase, olivenite, liebethenite, bournonite, and other beautiful copper minerals have apparently yet to be found.

Iron.

NATIVE IRON.

Out of a large number of specimens of so called native iron which have come before me from time to time, not one was entitled to be so called; they had all without exception been derived from iron and steel tools.

Native iron, apart from that derived from meteorites, however, probably does occur in the Colony, and it is most likely to be found in or near to igneous rocks, *e.g.*, melted globules of native iron have been met with at Ballaarat in Victoria in connection with basalt.

Magnetite.

Magnetic Iron Ore. Chem. Comp.: Iron oxide = $Fe_3 O_4$. Iron, 72·4; oxygen, 27·6 = 100. Cubical system.

This is the richest of all the ores of iron, and when perfectly pure it only contains rather more than 72 per cent. of metallic iron; hence the absurdity of the statement so commonly made that the iron ores on a certain property contain over 90 per cent. of metal will be at once apparent; and moreover, it is a very rare thing indeed for large masses of any ore to be quite pure, therefore, instead of the amount of metal in the vaunted mineral even approaching to that quantity it falls far below it, and most probably it is much nearer 50 than 90 per cent.

It is found in the Colony both massive and crystallized in octohedra, which are usually small. In structure it varies, being compact, granular or lamellar.

Large deposits of magnetite exist at Wallerawang; Mount Lambie, in a chloritic matrix; Mount Wingen; Solferino in quartz veins; Grafton with copper ores; on the Clarence and the Shoalhaven.

A lamellar magnetite of good quality occurs in quartz at Carcoar associated with iridescent botryoidal brown hæmatite, and at Combullanarang with copper ores.

It is also found at Inverary Quarry, where Stutchbury mentions that it occurs in the pisolitic form, associated with a black non-magnetic ore in rounded particles the size of peas, and cemented together by a variety of crystallized minerals. Crystallized and compact magnetite occurs near the limestone quarries on Belubula Creek. Rounded and polished nodules of magnetic iron ore occur in the Lachlan River with ilmenite; it is also found in nearly all the gold and gem bearing drifts and deposits.

Hæmatite.—Specular Iron.

Red Hæmatite, Specular Iron. Chem. comp.: Iron oxide $Fe_2 O_3$. Iron, 70; oxygen, 30 = 100.

Hexagonal system, in rhombohedral forms. Usually massive, platy, or micaceous. Well-formed crystals are almost unknown here. Specular iron ore occurs in a coarse-grained granite at Summer's Hill, near Bathurst, and at Mount Lambie; also at Bookham and Yass, with micaceous and massive red hæmatite; micaceous hæmatite also occurs at Pine Bone Creek, with titaniferous iron.

Of the hæmatite near Carcoar, the late Mr. Stutchbury speaks as follows:—"In a gully or creek called the Waterfall Creek, running into the Cardiangullong Creek, and at the extremity of a mountain spur known as the Rocky Ridge, there is an immense mass of oxydulous iron (hæmatite) forming in one solid mass a precipitous waterfall of about 60 feet in height; in this mass of

iron, especially in the joints, there are brilliant crystals of iron pyrites, with a small quantity of yellow copper ore and traces of blue and green carbonate of copper. Here also is found iron sulphate, from the docomposition of the pyrites."

In the cliffs at Shepherd's Hill, Newcastle, there are trunks of trees converted into red hæmatite.

Large deposits of massive and somewhat ochry red hæmatite occur at Brisbane Water, also over large areas in the County of Argyle. This same mineral enters largely also into the composition of the so-called "red hills" occurring in the New England tin districts and other parts. A silicious red hæmatite is also common in the Hawkesbury sandstone, about Sydney, and elsewhere, as veins and scattered nodules.

One of these nodules which I examined contained 28·0 per cent. of metallic iron, and the compact red hæmatite from Nattai gave me 45 per cent.

GOETHITE.—Brown Hæmatite.

Chem. comp.: Hydrated sesquioxide of Iron = $Fe_2O_3,3H_2O$. Iron sesquioxide, 89·9; water, 10·1 = 100.

Generally massive, or with fibrous radiate structure, minute velvety crystals are sometimes met with; also scaly, mammillated, pisolitic, reniform, and stalactitic.

Externally the colour is often jet-black with high lustre; within yellow, yellowish-brown, and full-brown. Streak, brown.

Many of the nodules of brown hæmatite contain cavities and hollows holding a soft black substance like binoxide of manganese, which hardens on exposure.

Very large and extensive irregular deposits and pockets of brown hæmatite occur at Wallerawang, Jamberoo, Nattai, Port Hacking, the Murrumbidgee, Mt. Tellula, and many other places, such as between Mt. Tomah and Mt. King George. In fact this mineral is one of the most widely diffused.

A specimen of Brown Hæmatite, from Wallerawang, yielded the following results on analysis:—

Water, hygroscopic	1·28	
„ combined	12·04	
Silica and insoluble matter...	12·19	
Sesquioxide of iron	73·60	= 51·2 per cent. metallic iron.
Phosphorus	·12	
Sulphur	·06	
Undetermined	·71	
	100·00	

Limonite.

A variety of brown hæmatite. Large stalactites are formed by the ferruginous springs at Berrima, Nattai, and elsewhere, and the deposits of brown iron from these often contain beautiful impressions of leaves and other objects; also in botryoidal and mammillated forms.

Extensive deposits of what are termed *Clay Band* iron ores occur interbedded with the coal measures. These form an earthy variety of brown hæmatite; yet they are often very rich, and as they occur in immense quantities in close association with coal, they form a most valuable source of iron.

A specimen from Wallerawang yielded the following results:—

Water, hygroscopic	1·28	
,, combined	3·54	
Silica and insoluble matter...	4·60	
Sesquioxide of iron	80·00	= 56 per cent. metallic iron.
Phosphorus	·49	
Sulphur	·11	
Undetermined constituents..	9·98	
	100·00	

Specimens from two other seams in the same locality yielded 49·28 and 53·31 per cent. of metallic iron respectively.

Similar clay bands occur at Jamberoo; in the Buttar Ranges, near to East Maitland; at Mount Wingen, and elsewhere.

Pisolitic Iron Ore—Is another of the less pure forms of Hæmatite.

Large superficial deposits of pisolitic and brecciated iron ore, red and brown, occur near Bungonia and Windellama Creek, and overlie the slate more or less continuously between Bungonia, Jacqua Creek (with limestone), Dog Trap, and Spring Creeks, forming what are known as the "Made Hills."

The "Made Hills" which lie between the Macintyre River and Cope's Creek are composed of the same material.

A pea-iron ore occurs in the coal at Nattai, and near Bungonia there is an auriferous argillaceous iron ore. At the Boro Creek, County of Argyle, there is a botryoidal pisolitic ore.

The same variety occurs at Brisbane Water.

Red and Yellow Ochres—Are closely allied to the above Hæmatite iron ores, and are usually found associated with them.

Spathic Iron Ore.—Chalybite.

Siderite, Sphœrosiderite.—Hexagonal system, rhombohedral forms.

Chem. Comp: Iron carbonate = FeCO. Iron oxide, 62·1; Carbonic acid, 37·9.

Occurs in minute crystals at Gulgong. It is also found at Newstead Mine, New England, with arragonite; in basalt, at Jordan's Hill, Cudgegong River.

Thick bands of grey-coloured impure carbonate of iron, some of which contain about 10 per cent. of metallic iron occur in the coal measures at Jamberoo.

Chrome Iron.—Chromite.

Chem. Comp.: Iron chromate = $FeCrO_4$. Iron oxide, 32·0; chromic acid, 68·0 = 100.

Cubical system: Usually occurs massive, with a granular or lammellar structure. Black in colour, and in small crystals and water-worn grains in gold and gem bearing sands.

In the Gwydir River and many of its tributaries, in Nundle Creek, Two-mile Creek, the Horton River, Hanging Rock, at Stony Batta with serpentine, Bingera, Reedy, Gundamulda, Kennedy's, and Angular Creeks; also at Mudgee, the Murrumbidgee River, and near Yass.

Scorodite.

Chem. Comp.: An arseniate of iron. Arsenic acid, 49·8; sesquioxide of iron, 34·7; water, 15·5 = 100.

Rhombic system: with iron pyrites, Cadell's Reef, Mudgee Road, 9 miles south-east of Mudgee.

Pharmacosiderite.

Chem. Comp.: Arseniate of Iron. Arsenic acid, 39·8.; phosphoric acid, 2·5; sesquioxide of iron, 40·6; water, 17·1 = 100.

Cubical system.—Found crystallized in small olive-green cubes. Subtranslucent.

Locality.—To the east of Bungonia.

Titaniferous Iron.

Chem. Comp.: Iron and titanium.

There are several different kinds of titaniferous iron, distinguished by their physical properties and by the amounts of titanic acid which they contain—such as ilmenite, iserine, menaccanite, &c. Until those found in New South Wales have been examined, it will it be as well, perhaps, to class them all under the general head of titaniferous iron.

Found usually with alluvial gold, about Ophir, Bathurst, Mudgee, Bingera, and Uralla in the diamond drifts. Large rolled masses occur at Uralla. Ilmenite, menaccanite, nigrine, and iserine are said to occur with gold, garnets, and chrysolites in the Two-mile Flat Creek Cudgegong River, and in the Lachlan with magnetite.

Iron Pyrites.

Chem. comp.: FeS_2. Sulphur 53·3; iron 46·7 = 100. Crystallizes in the cubical system. Occurs massive and crystallized, the most common forms being the cube and the pentagonal dodekahedron. Well-formed cubes partially decomposed into brown hæmatite are common in many deposits with gold, and are known to the miners by the name of "devil's dice." All specimens of pyrites which I have examined have without exception contained traces of gold, and in some cases large amounts.

As is found to be the case in other parts of the world, this mineral is almost universally diffused throughout the metalliferous districts of the Colony, and is found in rocks of all ages.

Well-formed crystals are found in the Manilla and Namoi Rivers. In the tin district of New England it is very common—Bathurst district; at Gulgong, well-formed pentagonal dodecahedra are common in the auriferous quartz veins. Very abundant in the Adelong reefs; the Carcoar District; at Kiandra, crystallized in cubes with molybdenite.

Marcasite.—Rhombic pyrites. Chem. comp.: Iron sulphide = FeS_2. Same as the former, of which it is an allotropic form.

Fluted rhombic crystals occur with arsenical and common pyrites (auriferous) to the south of Reedy Creek, Shoalhaven River; also at Carcoar, with galena and other minerals.

Pyrrhotine.

Magnetic pyrites. Chem. comp.: Fe_7S_8. Sulphur 39·5; iron 60·5 = 100.

Hexagonal system.

More of a copper-colour than the other pyrites, slightly magnetic, and crystallizes in six-sided forms.

It occurs with gold and calcite at Hawkins Hill.

Nickel.

Kupfernickel.—Copper-nickel.

Chem. Comp.: Nickel arsenide = NiAs., Ni = 44·1 : As = 55·9 = 100.

Hexagonal system: Massive. Of a copper-red colour, in parts incrusted with pale green nickel hydrate. Reported from near Bathurst.

Plakodine.

Arsenical nickel: NiAs., Nickel = 60 per cent.

Found by the Rev. W. B. Clarke, on the Peel River, and to the south-west of Weare's Creek. Yellowish white in colour, highly magnetic. Sp. gr. = 8; H. = 5·5; and dissolving readily in nitric acid.

Manganese.

The ores of manganese do not appear to have been discovered in any great abundance in New South Wales.

WAD.

An impure oxide of manganese.

At Long Gully, near Bungonia, it is met with having a more or less botryoidal form and platy structure; of a black colour, soft with a black shining streak; in association with quartz, both as small veins running through the quartz and as an external coating or incrustation. A specimen from this locality was found to contain 1·57 per cent. of cobalt, and 0·36 per cent. of nickel (Dr. Thomson.)

It is abundant in the diamond drift near Mudgee, both as a cement and incrustation; often dendritic in outline. The incrustation on many of the pebbles is evidently quite recent.

It is very common as dendritic markings on rocks in many parts of the Colony.

It is found to the north of Cotumba, loose on the ground; also at Orange.

A peculiar form of wad is found in cavities in the basalt at Hill End; this variety is very soft and porous, being composed of minute scales arranged loosely together in a concentric manner—in fact, having a structure similar to that of wood; externally it has somewhat a frothy appearance, with a metallic lustre; so soft that it blackens the fingers, and will hardly bear handling without crushing.

KUPFERMANGANERZ.

Cuprous manganese. Chem. comp.: An impure oxide of manganese, containing a few per cent. of black oxide of copper and oxide of cobalt.

Found in the Coombing Copper Mine, with native copper, cuprite, copper carbonates, and sulphides.

Zinc.

ZINC BLENDE.

Chem. comp.: Zinc sulphide = ZnS. Found massive, and crystallized in small hemihedral forms belonging to the cubical system. Many of the crystals have beautiful bronze and purple metallic tints.

With tin, gold, manganese, copper pyrites, galena, and other minerals, on Major's Creek, near Bungonia.

With gold, iron, copper pyrites, and asbestos, in a quartz vein, Wiseman's Creek, near Bathurst. Orange

Lead.

Native Lead.

The Rev. W. B. Clarke more than once mentions having found native lead on the Peel River and elsewhere.

Minium, or Native Red Lead.

Chem. comp.: Lead oxide = Pb_3O_4. Lead, 90·66; oxygen, 9·74 = 100. Occurs with cerussite at Peelwood, near Tuena.

Cerussite.

Chem. comp.: Lead carbonate = $PbCO_3$. Lead oxide, 83·5; carbonic acid, 16·5 = 100. Occurs massive and in large prismatic crystals at Peelwood Mine; on the exterior they are often coloured red by a ferruginous clay. Also found at Tuena in a red clay. At Solferino.

Anglesite.

Chem. comp.: Lead sulphate = $PbSO_4$. Lead oxide, 73·6; sulphuric acid, 36·4 = 100. Said to have been found with galena on the Abercrombie River.

Pyromorphite.

Chem. comp.: Lead phosphate = $3Pb_3P_2O_8$, PbCl. In round numbers, lead oxide, 75·0; phosphoric acid, 15·0; lead chloride, 10 = 100. Small quantities of calcium fluoride and calcium phosphate are usually present.

At Grenfell, it is found as a bright green-coloured powder containing minute hexagonal prisms; it is also found of the same colour associated with galena and mimetite in a vein traversing clay slate, near Bathurst. Another specimen from Bathurst was of a pale greyish-brown colour, with a waxy lustre, and mammillated surface, upon which small crystals of chessylite were seated.

It also occurs on the Sugar-loaf Hill, near Wellington; also on Mitchell's Creek.

Mimetite.—Kampylite.

Chem. comp.: Lead arseniate = $3Pb_3As_2O_8$, PbCl. In this mineral the phosphoric is replaced by arsenic acid. Of a brown colour, and in much-curved or barrel-shaped hexagonal prisms. With pyromorphite at Sugar-loaf Hill, Wellington.

Wulfenite.

Chem. comp.: Lead molybdate = $PbMO_4$. Lead oxide, 61·5; molybdic acid, 38·5 = 100. Mentioned as occurring on a spur of Mount Murulla, Kingdon's Ponds, and near Mount Wingen. Structure, radiate and waterworn. The Rev. W. B. Clarke also records finding drifted molybdate of lead, on the North Shore.

Galena.

Chem. comp.: Lead sulphide = PbS. Lead, 86·6; sulphur, 13·4 = 100. This, as elsewhere, is the commonest ore of lead; it not only occurs in large deposits, but it is widely distributed over the Colony.

It is usually found in the massive state, and with a granular structure which varies from fine to coarse. Occasionally it is met with fairly well crystallized, as at Cambalong, but on the whole crystals are rare. In other respects it presents all the usual properties of the mineral as found in other countries.

Localities—Near Inverell, and other places in New England; at Talwal Creek, on Yalwal Water; Reedy Creek; Wallabadah; on the Peel; the Page, Isis, and Hunter Rivers; at Burrowa, in quartz veins; with copper ores, on Lawson's Creek, a tributary of the Cudgegong; at Gulgong; Jugiong Creek; Crookwell River; Waroo, near Humewood; near Bathurst; Wellington; Sandy Swamp; at Mylora Creek, near Yass, in a quartz porphyry; at Woolgarloo, in association with fluor spar; near Bombala; at Kiandra, in quartz veins.

In all cases the galena is more or less rich in silver.

Tin.

Cassiterite.

Tinstone. Chem. comp: Tin binoxide = SnO_2. Tin, 78·67; oxygen, 21·33 = 100.

Tetragonal system. Occurs massive, crystallized, and as rolled pebbles and masses known as "stream tin." Well-developed crystals are by no means rare; the forms assumed are very similar to those found in other countries, viz., the prism, or a series of prisms combined with the pyramid, or pyramids, with and without the basal pinacoid plane. Sometimes the crystals are very large, especially those which are made up solely of the planes of the pyramid.

The lustre is usually bright metallic, hence many of the specimens are exceedingly pretty and brilliant, especially some of the ruby and amber coloured transparent specimens, which, however, have not as a rule so high a lustre as the black crystals; the colour varies from almost colourless and transparent, through shades of grey, yellow, amber, red, brown, to black, and opaque. Often more than one of these colours are to be seen in the same specimen, when the effect is very fine, especially the admixture of the ruby-red and translucent amber colours.

The hardness and sp. gr. do not appear to differ from tinstone obtained elsewhere.

The principal tin veins in New South Wales which have yet been worked, occur in granite at once seen to be similar to

that of Cornwall. In some parts, as at Elsmore and Newstead, New England, much of it occurs in veins of greisen (mica and quartz), and in eurite (felspar and quartz). At Newstead Mine, and also at the Albion Tin Mine, crystals of tin-stone are seen disseminated through large and well-formed transparent quartz crystals. At the former place the quartz crystals in which it occurs often weigh nearly a hundred weight.

It occurs in association with molybdenite, fluor spar, a yellow steatitic mineral, garnet, beryl, topaz, the matrix of the tin-stone is sometimes in places composed solely of topaz; malachite, copper and iron pyrites, mispickle, tourmaline or schorl, in radiated groups of crystals, and wolfram. I have not seen wolfram in the same veins, but in other veins in almost juxtaposition.

Wood tin occurs in veins at Glen Creek.

Alluvial tin deposits.—There are two distinct sets of tin drifts, an older and newer; the former commonly occur at a lower depth, they are generally much more compact and often cemented together into a hard conglomerate, usually so hard as to require stamping. The tinstone is also much rounded and waterworn; whereas the tinstone in the newer drift is bright, and has undergone but little attrition. Some of the fragments or pebbles of rolled tinstone weigh many pounds, notably on the Butchart Tin Mine.

The minerals found associated with the stream tin are much the same as those found with it *in situ*; but in addition we find gold in small quantities, diamonds, the sapphire, zircon, pleonaste, topaz often of large size, bismuthite, rutile, and others.

Up to the present, most of the tin has been obtained from the New England district.

Rolled *wood tin* of a grey and black colour, at Abingdon; also at Grenfell, with extremely well-marked concentric and radiate structure, composed of red, brown, and black bands, other fragments made up of alternate light and dark-grey bands. Also Lambing Flat and Grampian Hills.

Localities.—The Undercliff and Bookookoorara, in county Buller; Tea-tree Creek, tributary of Orara River; Mitchell and Henry Rivers (County of Gresham); Gordon's Creek, Glen Creek, Ranger's Valley, Shannon River, Severn River, Paradise Creek, Sheep-station Creek, Spring Creek, Stockyard Creek; Swan Creek, near Inverell; Yarrow River, Middle Creek, Auburn Vale Creek, Cope's Creek, Sandy and Moredun Creeks, tributaries of the Bundarra, Kentucky Ponds, Honey's Creek, Honeysuckle Creek, Gwydir and Rocky Rivers, Sandy Creek, Warialda Creek, Myall and Reedy Creeks; Bald Rock; Nangahra, Tiabundie, and Mount Lowry Creeks; Maryland and Herding Creeks; Boonoo Boonoo; Mount Mitchell and Oban, Sara and Ann Rivers, Uralla, Carlyle Creek, Deepwater, Mole River, and Sandy Mount; Bende-

meer in greisen; Quirindi, and Carroll's Creeks; Turon River, Shoalhaven River; Long Gully and Spring Creek, near Bungonia; Burra Creek, County of Selwyn; Dabarra, Jingellie Creek; at Mowemban in quartz associated with chalcedony. Vein tin occurs in quarries at Billabong, near Wagga Wagga. Rolled wood tin, with the diamonds near Mudgee and Bathurst; Tumberumba, with gold.

The first public mention made of the occurrence of tin in New South Wales was by the Rev. W. B. Clarke. In the *Sydney Morning Herald*, August 16th, 1849, he records having found it in the Alps along part of the Murrumbidgee.

Mr. Clarke mentions having found tinstone pseudomorphous after felspar crystals in New England.

In the *Papers relating to Geological Surveys* published by the Government, I find that Mr. Hargraves makes the following mention of tin ore in New South Wales:—

P. 71. "Guntawang, 18th July, 1851.

"I have received information from Mr. Rouse of this place (Guntawang) that a shepherd of his found tin at Warrambungall Mountain some years ago, distant 100 miles north of this place. I have therefore determined to visit the locality, and start for that place to-morrow, &c.

"E. H. Hargraves."

P. 72. "Mudgee, 3rd August, 1851.

"In travelling 6 miles N.W. of the Cudgegong, I found the gold region ceased; and on arriving at the Warrambungall Mountains, 100 miles N.W., I found coal and iron in great abundance on every hill, but was not successful in finding the tin. The shepherd who knows the locality gave me a piece which he had smelted into bars, a sample of which I herewith enclose, which I should suppose contains 30 per cent. of silver, and in a short time the locality will be known to me. The man wants a large consideration for disclosing the whereabouts at present.

"E. H. Hargraves."

Amount of tin ore raised from 1872 up to the end of 1874 was valued at £866,461.

Titanium.

Rutile.

Chemical composition: Titanic acid = TiO_2. Crystallizing usually in tetragonal prisms. Up to the present time I have only found it in the form of fragments of crystals with striated surfaces, or in rounded grains of a hair-brown colour. It is found with the gem sand from Bald Hill near Bathurst and at Uralla.

Brookite.—Which is an allotropic form of titanic acid, crystallizing in flattened forms belonging to the rhombic system, has also been found in New South Wales.

In the diamond drift near Mudgee as flat, transparent, red and translucent reddish-white plates, with striated surfaces. H = 6, and sp. gr. = 4·13. Chem. comp.: Pure titanic acid, except a minute trace of iron oxide (Dr. Thomson).

Anatase.—A third allotropic form of titanic acid, crystallizing in tetragonal pyramids. This has been found at the dry diggings of Burrandong.

Sphene.

A calcium silico-titanate. Locality is uncertain; I have met with but one well crystallized specimen, of a green colour.

Tungsten.

Wolfram.

Iron and manganese tungstate = $(FeMn)WO_4$. It is found in rolled masses in association with tin-stone in many parts of New England. It is also found *in situ* in the quartz veins on Elsmore, Newstead, and other places, in the usual form of imperfectly developed tabular crystals. It is commonly accompanied by iron pyrites.

Scheelite.

Calcium tungstate = $CaTiO_3$. Probably occurs in New England.

Molybdenum.

Molybdenite.

Chemical comp.: Molybdenum sulphide MoS_2.
Usually found massive with a coarsely granular structure; also in grains, scales, plates, and rosette clusters of crystals. Sometimes the flat hexagonal plates or crystals are of large size; I have found some as large as a half-crown on the Elsmore Tin Mine.

The colour is usually bluish-white, with a strong metallic lustre.

Associations.—It is rather common in the New England tin districts, especially at the Elsmore and Newstead tin mines, where it occurs in the tin veins traversing the granite. It is most usually associated with quartz. On the Hunter River it is found associated with gold, galena, pyrites, and other minerals.

Localities.—It also occurs at Bullin Flat, near Goulburn, at Kiandra with quartz, and Cleveland Bay.

Arsenic.

Native Arsenic.

In massive pieces with mammillated surface, Lunatic Reef, Solferino.

Mispickle.—Arsenical Pyrites.

Chem. Comp.: Sulp-arsenide of iron $FeS + FeAs$.

Arsenic, 46·0; sulphur, 19·6; iron, 34·4 = 100. Rhombic system. Colour almost silver white. Streak dark-greyish black.

Rather large crystals occur with quartz near Goulburn, also Shoalhaven River associated with small hexagonal prisms of beryl, which penetrate the mispickle. In New England, Elsmore, and other places. Near Orange, very rich in gold. On the Moama or Mitchell River near Cooradooral.

At Carcoar, with marcasite and common pyrites. Gulgong.

Occasionally the mispickle is exceedingly rich in gold.

Tellurium.

Native Tellurium.

A rare metal—reported to occur at Bingera.

Antimony.

Native Antimony.

I can find no authentic record of the occurrence of native metallic antimony in New South Wales, although I believe it has been met with in New England and elsewhere.

Antimonite.

Chem. Comp.: antimony sulphide $= Sb_2S_3$.

$Sb = 71{\cdot}8$; $S = 28{\cdot}2 = 100$.

This ore is met with in the massive state in mineral veins, and occasionally in rolled masses; crystals appear to be rare.

It occurs on the Clarence and Paterson Rivers, the mineral occuring in masses of large size, and showing broad, well-defined, striated cleavage planes, portions of the surface usually being incrusted with a yellow coating of cervantite, an oxide of antimony $= Sb0_4$.

It is found associated in many parts of New England with tinstone, molybdenite, wolfram, and other minerals.

Localities.—Tenterfield, Armidale, Gresford, Rylstone, Rocky River, Grafton, Macleay and Hastings Rivers, near Mt. Mitchell, Boorolong, Gara, Drake, Nundle Gold Field, Solferino, Wallerawang, Gundagai, Shoalhaven River, Eden, Twofold Bay.

The Rev. W. B. Clarke records finding a rolled mass on the North Shore.

Cervantite.

Chem. Comp.: Antimony oxide = SbO_4. Sb = 79·2; O = 20·8 = 100.

Usually occurs massive, as an incrustation upon antimonite sometimes as minute circular crystals of a dull yellow colour.

Localities.—Almost the same as those for antimonite, as at Gwyra near Armidale, Pyramul, and other places.

Jamesonite.

Chem. Comp. = 2 (PbFe) S + Sb_2 S_3.

Sulphur, 21·1; antimony, 32·2; lead, 43·7; iron 30 = 100.

This mineraly usually occurs in fibrous masses of a bluish lead-grey colour.

It occurs with cervantite in a soft quartz near to Campbell Creek and Nuggety Gully, Bathurst district.

Bismuth.

Native Bismuth.

Found in the New England District between Oban and Tenterfield. This metal is now becoming very valuable.

Bismuthite.

Chem. Comp.: A hydrated carbonate of bismuth. Bismuth oxide, 90·0; carbonic acid, 6·5; water, 3·5 = 100.

Found in the form of more or less rounded grains and pebbles with stream tin in the New England district.

PART II.

NON-METALLIC MINERALS.

CLASS I.

Carbon and Carbonaceous Minerals.

DIAMOND.

Chem. comp.: Carbon. Cubical system. The first mention made of the existence of the diamond in New South Wales, which I have been able to find, is one by Mr. E. H. Hargraves, who, in his report, dated from the "Wellington Inn," Guyong, on the 2nd July, 1851, refers to some enclosed specimens of gold, gems, and "a small one of the diamond kind," from Reedy Creek, 16 miles from Bathurst. The next record of the occurrence of the diamond in New South Wales appears to have been made by the Rev. W. B. Clarke, in an appendix to his "Southern Gold Fields," published in 1860; he records that four were brought to him on September 21st, 1859, which were obtained from the Macquarie River, near Suttor's Bar; the crystalline form which they exhibited was that of the triakisoctohedron or three-faced octohedron, and one of them had a sp. gr. of 3·40. Another which was received from Burrendong, on December 29th, 1859, had a sp. gr. of 3·50. One from Pyramul Creek, crystallized in the hexakis or six-faced octohedron, weighed 9·44 grains, and had a sp. gr. of 3·49. Another was sent to him in August, 1860, which had been found in the Calabash Creek by a digger as far back as 1852.

Diamonds were found by the gold diggers on the Mudgee Diamond Diggings in 1867, but were not especially worked until 1869. The diamonds were obtained from outliers of an old river-drift which had in parts been protected from denudation by a capping of hard compact basalt. This drift was made up mostly of boulders and pebbles of quartz, jasper, agate, quartzite, flinty slate, silicified wood, shale, sandstone, and abundance of coarse sand mixed with more or less clay.

Many of the boulders are remarkable for the peculiar brilliant polish which they possess. The principal minerals found with the diamond are gold, garnets, woodtin, brookite, magnetite, ilmenite, tourmaline, zircon, sapphire, ruby, adamantine spar, barklyite, common, and a peculiar lavender-coloured variety of corundum,

quartz, topaz, magnesite and nodules of limonite which had been set free from an impure magnesite, black vesicular pleonaste, spinel, ruby, and osmo-iridium.

The largest diamond found weighed 16·2 grains, or about $5\frac{5}{8}$ carats.

The average sp. gr. was 3·44, and the average weight of a large number of those obtained was but 0·23 carat. (For further particulars, see paper on the Mudgee Diamond Fields, by Professor Thomson and Mr. Norman Taylor, in the Trans. Roy. Soc. N.S.W., 1870.) The total number found has been stated roughly at about 6,000; the number also from Bingera must be nearly as many—in all, say, 10,000 at least.

In colour they vary from colourless and transparent to various shades of straw, yellow, brown, light-green, and black. One of a rich dark-green was found in the form of a flattened hemitrope octohedron.

The most common crystalline forms which have been met with are the octohedron the hemitrope octohedron, the rhombic dodecahedron, the triakis and hexakis octohedron. The flattened triangular hemitrope crystals are very common; one specimen of the deltoidal dodecahedron was met with.

The lustre is usually brilliant or adamantine, but occasionally they have a dull appearance. This is not due to any coating of foreign matter or to the same cause as the dulness of less hard waterworn crystals; but it is owing to the presence of innumerable edges and angles belonging to the structure of the crystal; these reflect the light irregularly at all angles and give the stone its frosted appearance.

The diamonds at Bingera occur under almost exactly the same circumstances as at Mudgee, and with the same minerals, except that I did not come across either the black vesicular pleonaste or barklyite.

From a series of determinations made on nineteen of the Bingera diamonds, I obtained a mean sp. gr. of 3·42. (For details *vide* paper upon the Bingera Diamond Fields—Trans. Roy. Soc., N.S.W., 1873.)

Diamonds have also been found at Bald Hill, Hill End, with the same gems as at the above-mentioned places; one octohedral crystal, rather flattened, which I examined, weighed 9·6 grains (troy) and had a sp. gr. of 3·58.

A specimen of "bort" or black diamond was presented to me by Mr. J. R. Peebles, of Sydney, which was obtained near Bathurst; it is of about the same size as a large pea, black in colour, with a graphitic or black-lead lustre; it is very nearly spherical in form, but has a few slight irregular processes, which seem to be due to an attempt to assume the form of the hexakis octohedron.

In weight it is 7·352 grains (troy), and at 70° F. the sp. gr. is 3·56.

Mr. Wilkinson mentions, that from the Bengonover Tin Mine, near the Borah Tin Mine, several diamonds were obtained, the largest being 7·5 grains. From the Borah Tin Mine, situated at the junction of Cope's Creek with the Gwydir, 200 were obtained in a few months; out of a batch of 86, averaging 1 carat grain each, the largest weighed 5·5 grains. Diamonds have been found on most of the alluvial tin workings at Cope's, Newstead, Vegetable, and Middle Creeks, and elsewhere in the district.

Amongst other places the diamond has been found in the Turon, the Abercrombie, the Cudgegong, Macquarie, and Shoalhaven Rivers. One was found in August, 1874, in Brook's Creek, Gundaroo, near Goulburn, valued at £3. At Uralla, Oberon, and Trunkey, they are by no means uncommon; and I have recently obtained a small hemitrope octohedron from the Lachlan River weighing 1·5 grains.

Diamonds have also been obtained from diggings on the seashore near to Ballina.

A drift having almost exactly the same characters as those at Bingera and Mudgee, occurs at Wallerawang, and on the Mary River, Queensland—even to the presence of masses of conglomerate of jasper, quartz, and other pebbles agglutinated together by a ferruginous and manganiferous cement.

GRAPHITE.—Plumbago.

Chem. comp.: Carbon. Hexagonal system. Occurs with quartz, iron pyrites, and pyromorphite at the head of the Abercrombie River, possesses a curved lamellar structure. Occurs in small radiating masses in the granite at Dundee, in New Valley, and near Tenterfield.

Reported also from Bungonia, but its existence there is doubtful; also from the Cordeaux River, near Mt. Keira, and Plumbago Creek near junction of Timbarra Creek, county of Drake.

Small particles are not uncommon in the sandstone about Sydney and other parts.

Any black clay or other substance which can be made to leave a mark on paper is brought into Sydney as a sample of a most valuable deposit of graphite. I have not yet seen, out of many highly extolled specimens, one fit for even the commonest purpose.

COAL.

As a mineral there is not much to be said about the coal of New South Wales, as there is no very material difference between it and that of England. The coal from certain mines is caking, and from others non-caking, *i.e.*, it will not furnish a coke. The

amount of ash varies considerably, the coal from some of the Northern pits not containing more than about 2·0 per cent., while some of the Western and Southern coals contain from 8 to 14 per cent. In some cases the seams are from 30 to even 40 feet in thickness.

Localities.—Owing to coal being widely distributed over New South Wales it would be almost an endless task to mention the names of places under which it lies or at which it crops out, it must therefore suffice to refer the reader to the mineral map published by the Government.

The area of the various coal fields of New South Wales is approximately estimated at some 24,840 square miles.

The amount of coal raised during the year 1874 was in round numbers :—

Northern Gold Fields	1,126,000
Southern do.	137,000
Western do.	44,000
Total	1,305,000 tons.

Valued at about £975,000.

For analyses of the coal raised by the various pits in New South Wales, I must refer you to my report made to the Mining Department, and now in course of publication by the Government; but there are one or two other analyses which are not included in that paper; the following is by Mr. Rich. Smith of the School of Mines, London :—

Bulli Coal.

Carbon	75·57
Hydrogen...	4·70
Oxygen and Hydrogen	4·99
Sulphur	0·54
Ash	13·17
Water	1·03
	100·00
Coke	74·78
Volatile gaseous matter	24·19
Water	1·03
	100·00

Sp. gravity = 1·471.

Some analyses of the Wallerawang Coal gave the following results :—

A sample from a seam 17 feet 6 inches thick gave :—

Moisture	1·51	
Volatile hydrocarbons ...	33·24	
Fixed carbon	55·74	Coke = 65·24 per cent.
Ash, white	9·50	
	99·99	

Sp. gravity = 1·333.

Another seam 6 feet 6 inches thick :—

Moisture	1·95	
Volatile hydrocarbons ...	27·25	
Fixed carbon	61·86	70·80 per cent. coke.
Ash, white	8·94	
	100·00	

Sp. gr. = 1·398.

The coal from the Waratah Company's mine is sometimes beautifully iridescent. And in the Australian Agricultural Company's Borehole pit, nodules of hard and compact anthracitic coal are met with in the substance of the softer coal.

Coal containing pea-iron ore is abundant at Nattai. Another coal, from near to Nattai, is very brilliant in lustre, and breaks with a pitchy lustrous conchoidal fracture like albertite; it is also marked by the presence of thick layers of "mother-of-coal" or fibrous mineral charcoal.

A splintery anthracite is said to occur at Gordon Brook, in the county of Richmond. As far as I have seen at present, only one of the so-called New South Wales anthracites are really deserving of that name, the others are merely very poor or else baked coals, *i.e.*, coal which has been more or less destroyed by the intrusion of a dyke of some igneous rock.

LIGNITE.—Brown coal.

Chem. comp. : Carbon, hydrogen, oxygen, and ash. This substance may be looked upon as an imperfect coal. In some cases it still retains the original fibrous woody structure; in other cases it is scaly or massive.

Found at Kiandra. Brown, but black in parts, with a pitchy lustre; fracture subconchoidal; exhibits woody structure. On the Lachlan River, where it possesses a platy structure; found also on Mr. Berry's land, at the mouth of the Shoalhaven, at a depth of 12 feet; also at Turalla Creek, County of Argyle, retains original structure of the wood, and has much the same appearance as "bog oak."

Resinite.

Reported to occur on the Clarence River.

Bog Butter.

A white, soft, somewhat unctuous substance, found betweeu Twofold Bay and Brogo. Mentioned by the Rev. W. B. Clarkc.

Mineral Wax.—Ozo-kerite.

Chem. comp.: Carbon, hydrogen, and oxygen. Of a brown-grey colour. Breaks with a subconchoidal fracture. Coola.

Bathvellite, or Torbanite.

Found at Mt. York and Macquarie Fields.

Elaterite.—Elastic bitumen.

Chem. comp.: Carbon, hydrogen, and oxygen. At Reedy Creek or Petrolia there is said to be a band of thin and very elastic substance like elaterite.

Kerosene Shale.

This mineral is found abundantly in the coal measures of New South Wales, usually in the form of more or less lenticular deposits. The name wollongongite was given to it by Dana, but the term has never come into general use.

In colour the mineral varies from brown, sometimes a greenish-brown, to jet black. It usually weathers white, and as the surfaces of the joints are also usually coated with a thin film of a white clay-like substance, the mineral is sometimes termed "*White Coal.*" The fracture is usually large conchoidal. When struck it gives out a woody sound. Can be cut by the knife into comparatively thin shavings. Gives a black shining streak and a brown powder. Thin sections, under the microscope, show an amber, brown, and black reticulated structure. The brown portions are those which transmit the light, and the black the opaque portions. Mr. E. T. Newton, assistant naturalist to the Geological Survey of England, has recently written a valuable and interesting paper upon the microscopic structure of the so-called white coal and tasmanite of Tasmania. (See Geol. Mag., Sept., 1875.)

Chemical Composition.

Different samples vary very much in composition. From analyses which I have made, the following results were obtained:—

Greta.

Moisture	·48
Volatile hydrocarbons ...	61·66
Fixed carbon	25·13
Ash (grey)	13·21
	100·00

Murrurundi.

	(1.)	(2.)
Moisture	1·00	1·01
Volatile hydrocarbons ...	66·33	71·70
Fixed carbon	6·27	6·17
Ash (grey)	26·40	21·12
	100·00	100·00

	Hartley.	*Wollongong.*
Moisture ... ... / Volatile hydrocarbons } ...	82·24	82·50
Fixed carbon	4·97	6·50
Ash...	12·79	11·00
	100·00	100·00

Specific gravity = 1·052.

From the Hartley specimen, the ash was pinkish grey.

The analysis of the specimen from Wollongong was made by Prof. Silliman.

A very similar shale is found in New Caledonia; the physical properties are very similar, and the chemical composition is shown by the following analysis:—

Moisture ... ... / Volatile hydrocarbons } ...	65·17
Fixed carbon	8·71
Ash	26·12
	100·00

Specific gravity = 1·238.

Some of the Hartley shale has been known to yield as much as 180 gallons of crude oil per ton.

Some specimens from Hartley give on fracture very long flexible concavo-convex flakes. Again, some shales like those from Murrurundi are full of little specks of a white aluminous pipeclay like mineral.

The kerosene shale when heated in a tube neither decrepitates nor fuses, but there distils over from it a mixture of gaseous and liquid hydrocarbons.

It is found at Stony Creek, Berrima, Wollongong, American Creek, near Murrurundi; Greta, Lake Macquarie, and Hartley.

Jet.

A true jet which takes a high polish and breaks with a conchoidal fracture, occurs as occasional layers in the Hartley shale.

CLASS II.

Sulphur.

NATIVE SULPHUR.

Occurs in small quantities as a sublimate from the vents of Mount Wingen, the so called "Burning Mountain," in association with iron sulphate and various other salts.

CLASS III.

Salts.

COMMON SALT.

Chem. comp.: Sodium chloride. Common in most spring waters; occasionally found as an incrustation from the evaporation of lakes and waterholes.

NATRON.

Chem. comp.: Hydrated sodium carbonate. Said to occur as a deposit from the Mud Wells in the Namoi Scrub.

CLASS IV.

Earthy Minerals

BARYTES.—Heavy spar.

Chem. comp.: Barium sulphate. Rhombic system. It occurs with fibrous and massive green carbonate of copper, copper pyrites, and galena, at Cambalong, Merinoo.

SELENITE, or Gypsum.

Chem. comp.: Hydrated calcium sulphate. Rhombic system. Found crystallized in clay on the Darling River. Also on the Bogan River. Of commercial value for the manufacture of Plaster-of-Paris and other cements.

ARRAGONITE.

Chem. comp.: Calcium carbonate.

Rhombic system. Good crystals of this form of carbonate of lime are perhaps more common than of the former mineral calcite, especially in connection with stalactites and as enclosures within the amygdaloidal cavities of basalt.

Beautiful groups of crystals and bunches of *flos ferri* have been obtained from the limestone caves at Lob's Hole, the Coodradigbee, the junction of Cotton's River and the Murrumbidgee; and from near Bungonia. It also occurs at the Cataract River, and fair specimens of stalactitic arragmite are to be seen at Port Hacking. The more or less spherical concretions termed "cave pearls" by Professor Boyd Dawkins, F.R.S., are also found in some of the above caves notably from those at the Coodradigbee.

Arragonite occurs in vesicular basalt at Cherry-tree Hill near Mudgee, and groups of radiating crystals several inches in length are met with in a similar rock at Inverell; Jordan's Hill, Cudgegong; at the Brick Kiln, Rock Flat, in radiate columns or crystals of variegated green and white colours.

Calcareous Tufa, or Fresh-water Limestone.—At Burragorang, Quialago Creek, Goulburn Plains, and at Newstead Station, New England.

CALCITE.—Iceland spar.

Chem. comp.: Calcium carbonate. Hexagonal system. Sometimes well-developed crystals are met with. The usual forms are rhombohedra and their combinations, also combined with the terminal pinacoid or O.P. plane, and occasionally scalenohedra. I have not as yet observed the prism amongst the New South Wales forms.

The localities for calcite are extremely numerous, as it is met with wherever limestone occurs, and is a common substance in mineral veins.

Large well-developed flat rhombohedral crystals of calcite occur, associated with quartz, in the joints and cavities which exist in the basalt of the Pennant Hills, near Parramatta. It is also met with in the quartz veins in association with and as the matrix of gold, as at Gulgong and other places. It is sometimes present in the joints in sandstone, as at the Cataract River.

Opaque white calcite occurs at Capertee.

Marble.—Several beds of very fine marble, or crystalline limestone, occur in different parts of the Colony, as at Wollondilly, whence one of the marbles, used in paving various public buildings in Sydney has been obtained—as the great hall at the University, and at the Post Office. Much of the Wollondilly so-called "white marble" is of a creamy tint, variegated with pale red and light blue streaks. A slate-coloured marble, used in the same buildings, is brought from Marulan, near Goulburn. There is a beautiful white marble near Bathurst, and a brecciated slate-coloured one streaked with white at Wallerawang and other spots between the above two places. Beautiful marbles occur at Mudgee and Orange; also at Wellington, celebrated for its caves. At Bangalore, on the Goulburn Plains, there is found a white crystalline marble. At Yass. Queanbeyan. Good grey and white crystalline marbles are found along the banks of the Murrumbidgee. There are many caves in the limestone between the Belubula River and the Conomodine Creek, in the Orange district, containing animal remains, some of which are of considerable size. Blue-grey limestone at Warialda. The outcrops of small seams of grey crystalline limestone or marble are seen exposed in the Minumurra Creek, near Jamberoo, interbedded with the coal, shale, and sandstones of that district.

Oolitic Limestone.—A limestone of this structure is said to occur on the Page River.

Concretions.—Calcareous concretions are common in the black and chocolate coloured soils of igneous origin, which occur in various parts of the Colony, such as on the Liverpool Plains, New England, Gwydir district, Hunter River district, and at Scone, and in numerous other localities where there is a soil derived from the decomposition of a basaltic or other igneous rock.

Strontianite.

I have not yet met with any strontium minerals in New South Wales.

Apatite.

Chem. Comp.: Chloro-phosphate of calcium. Crystallizes in the hexagonal system, in the form of six-sided prisms. It is reported to occur in well-formed crystals with bitter spar on the Lachlan, between Boco Rock and Wog-wog, and with graphite and quartz at the head of the Abercrombie River; also on the Clarence River.

This mineral is of considerable commercial value.

Wavellite.

Chem. Comp.: A hydrated aluminium phosphate. A yellow mineral, reported to be Wavellite with a radiate structure is found in the fissures of felstone pebbles common in Rat's Castle Creek, Two-mile Flat, Mudgee.

Fluor Spar.

Chem. Comp.: Calcium fluoride. Crystallizes in the cubical system.

Up to the present it has apparently only been found in the massive state, or in but very imperfect octohedral crystals. This mineral has been met with in several places in the New England district, near to Inverell, at Elsmore; at the Boundary, Sydney and Caledonian Tin Mines, on Cope's and Middle Creeks, where it is found in association with tinstone, a green steatitic clay, copper pyrites, galena, quartz, molybdenite, and other minerals, all of which may often be seen in one hard specimen.

It also occurs at south Wiseman's Creek in association with copper ores; in certain cases the fluor is much fissured, and the cracks are filled in with red oxide and blue carbonate of copper, which impart to the mineral a very pretty and ornamental appearance, and it would in consequence probably serve for inlaid work. At Woolgarloo Lead Mines it is found in the massive state as the matrix of galena; it is usually opaque or but semi-translucent white with pale-bluish or purple veinings.

At Mount Lambie Mr. Wilkinson reports its presence in the Devonian beds.

Epsomite.

Chem. Comp.: Hydrated magnesium sulphate. Occurs as an efflorescence in the caves of the Hawksbury sandstone; usually masses of fibrous crystals are met with sometimes five or six inches in length, of a beautiful white silky lustre. The crystals are usually curved towards the free end; also in radiate groups of small crystals. Very fine specimens have been obtained from Dabee, Wallerawang, and Mudgee, the Great Western mines, Icely, and Barragorang.

Magnesite.

Chem. Comp.: Magnesium carbonate. Crystallizes in the hexagonal system, usually as rhombohedra; but no well-developed crystals have yet come under my notice. It is most commonly found massive, or in concretions, having a mammillated or botryoidal form. H. = 4 to 5. Sp. gr. = 2·94.

It is found in New England in various places, and upon the Diamond Fields at Bingera, and near Mudgee; when impure it is of a gray or gray-brown colour, but when pure it is of a dazzling white; compact, tough, and breaks with a flat conchoidal fracture. It adheres to the tongue, and has a very cold feel like porcelain.

It effervesces with hydrochloric acid, but with difficulty.

At the diamond diggings at Two-mile Flat, near Mudgee, pure white magnesite was observed to form by the spontaneous decomposition of the heaps of refuse from the miners' shafts; pebbles were quickly cemented together by it.

The late Dr. Thomson of the Sydney University found that the magnesite thus formed, and incrusting rubbish heaps, timber, old tools, etc., had the following composition:—

Magnesia	46·99
Carbonic acid	49·78
Water	4·08
	100·85

Sp. gr. = 2·94.

This magnesite sometimes contained calcite. It was also observed under the same circumstances on Cunningham's Diggings on the east side of Cudgegong Creek, and there with a peculiar vermicular or worm-like form.

Another locality is the Lachlan River.

Sulphate of Alumina.

Chem. comp.: Hydrated aluminium sulphate. Commonly called "alum," from its astringent taste, but potassium is absent from the mineral.

Commonly met with as an efflorescence in caves and under sheltered ledges of the coal measure sandstone, as at Dabee, Wallerawang, Mudgee Road, the mouth of the Shoalhaven River, and other places where it is usually associated with epsomite. Also found in the crevices of a blue slate at Alum Creek, and at the Gibraltar Rock, Shoalhaven. Occurs as a deposit with various other salts from the vents at Mount Wingen, together with native sulphur in small quantities.

Websterite.

Chem. Comp.: Aluminium sulphate. Reported to occur on Brush Creek, Dumaresq River.

Silica.

Quartz.—Rock crystal.

Chem. comp.: Silica. Hexagonal system. Found in nearly all parts of the Colony, and in crystals more or less perfectly developed; the most common form is the prism combined with the pyramid. Occasionally prisms closed at both ends by planes of the pyramid; also double pyramids. Such crystals are, however, usually small and generally occur in quartz porphyries, or are derived from the decomposition of such.

Occasionally some very large crystals are met with, notably at Newstead Tin Mine, New England, where, in one of the shafts, crystals nearly one cwt. were met with; within these, crystals of tinstone were often found disseminated.

Large crystals of smoky quartz are common almost throughout New England, as at Bingera, Inverell, Cope's Creek, Uralla, and at Mudgee. Some of the rock crystals found in the alluvial tin deposits present a very pretty appearance, from the presence of numerous minute fissures and internal films, streaks and patches of yellow, orange, and red colours. Most of the crystals from New England have one face of the pyramid much more largely developed, so much so in some cases as to almost obliterate the others.

Elongated pyramids containing disseminated crystal of cassiterite are common at the Albion Tin Mine; these crystals of quartz are dull and slightly rough on three of the faces, and bright on the opposite three.

Smoky brown Cairngorum and limpid quartz crystals are plentiful in Ranger's Valley, River Severn; Macintyre River, Middle Creek, Byron's Plains.

Quartz crystals with rounded edges and dull surfaces, as if acted upon by hydrofluoric acid, occur in the coarse-grained granite on Mann's River.

Quartz crystals are common near the junction of the Turon and Macquarie Rivers; at Bukulla, clear and brilliant crystals; from the Diamond Mountain, Cudgegong, Macquarie River, in anamygdaloidal basalt, Deep Lead, Gulgong Rush; at Carcoar, containing lamellar magnetite, also with a pale blue quartz. Well-developed and brilliant crystals from Bullamalite Creek, a tributary of the Mulwaree, near Goulburn, at Gurragangamore and other places on the Goulburn Plains; the Lachlan River, Cooma, Kiandra, the Murrumbidgee; in the Naas Valley, with tourmaline and schorl; between Pambula and Eden, with molybdenite.

Up to the present the number of substances which I have observed enclosed within quartz crystals found in this Colony is not great.

Endomorphs in Quartz Crystals.

1. Actinolite—Morvembah, Morendee, on the Meroo, a tributary of the Cudgegong.
2. Asbestos—Uralla.
3. Cassiterite or Tin-stone—Albion and Newstead Mines, New England.
4. Epidote—Towamba and Maneero.
5. Argentiferous Galena—Near Summer's Hill, Bathurst.
6. Gold—Boro Creek and other places.
7. Graphite—Head of Abercrombie River.
8. Orthoclose felspar—Two-Mile Flat, Mudgee.
9. Molybdenite—Bullio Flat, near Goulburn.
10. Rutile.
11. Schorl and tourmaline—Murrumbidgee.

Pseudomorphs.

That is, quartz possessing the external form of other minerals. Quartz after calcite—Gulgong, Yass, and Bathurst; also, often iron pyrites and mispickle.

Amethyst.—A pale purple-coloured variety of quartz. It occurs as geodes in the basalt at Kiama; the crystals are usually small, not being more than $\frac{3}{8}$ of an inch through. Found also at Dubbo. A quartz vein containing amethystine quartz occurs near the top of Bullabalakit.

Agate.—Agates consist of mixtures of crystalline quartz and chalcedony, usually arranged in concentric layers and bands; their structure is caused by the peculiar mode of formation, viz., by the infiltration of silica into the amygdaloidal cavities of igneous rocks.

They are common in the basalt at Kiama, near Scone, Inverell, and other places, and are very plentiful in the beds of many of the rivers and old drifts of New South Wales, as in the Mackintyre, parts of the Gwydir, the Hunter, the Cookaboo, where they are derived from the basalt of the Western Range or Dewingbong Mountain.

Agates and chalcedony are plentiful near Dubbo and Bald Hill, Wellington, Mount Wingen, Maitland, Cowriga, and other places.

Jasper.—Is very abundant and widely distributed throughout various parts of New South Wales. It is found of nearly all shades of colour—pure white, grey, slate, dull blue, olive and bright greens, brown, red, and black, both alone as simple colours, and in varied combinations of stripes, streaks, and bands and mottlings.

It is found mainly in the form of boulders and pebbles in river beds, and it enters largely into the composition of nearly all conglomerates, gravelly alluvial deposits, and river drifts.

The peculiar variety known as Egyptian jasper does not appear to have yet been met with.

Amongst the principal localities are the Gwydir, the Mackintyre, the Macquarie, Cudgegong, the Hunter, the Murrumbidgee, and many of their tributaries. There are large quantities of fine red jasper near Gobolion; also near Scone. The drifts at Mudgee, Bathurst, Bingera, Lake George, Molong, and other places are rich in fine jasper specimens.

Ribbon Jasper.—At the junction of Pink's Creek with the Bell River a clay slate has been converted into ribbon jasper.

Eisenkiesel.—A variety of ferruginous quartz. Large masses of this mineral *in situ* occur near Bingera; it also abounds between Guano Hill and the Bell River, at Carcoar, Mount Lindesay, and at the junction of Cotter's River with the Murrumbidgee.

Lydian Stone.—A velvet black form of jasper, used by jewellers as a touchstone for gold alloys. Mullion Range, Bathurst country.

Chert.—Common in seams and bands throughout the coal measures. Its structure is often more or less lamellar, and the fracture conchoidal. Mount Victoria, Wallerawang, Hartley, Jamberoo, Illawarra, Lachlan River.

Chalcedony.—An amorphous or crypto-crystalline form of quartz. There are several varieties of chalcedony.

Chalcedony proper: Massive, translucent, pale-grey, blue, or brown; with waxy lustre; surface mammillated, and often of a stalactitic form.

Nodules of chalcedony are found near Carcoar, with resinite and chert; also at Cowriga Creek, Wellington, Dubbo, Maitland, the Hunter River, and filling lines of small cavities in a green felstone on Rat's Castle Creek, 6 miles S.E. of Two-mile Flat.

Carnelian: Is a bright red chalcedony, but the ornamental white varieties of chalcedony are also usually included under the same name by jewellers.

Red and white carnelians are rather common in the Hunter River, or Maitland, and other places; also near Wellington; in Pond Creek, near Inverell.

Opal.

This mineral consists of silica, with usually from 5 to 12 per cent. in water.

Precious or *Noble Opal:* The precious opal of New South Wales has the milky body colour usually possessed by this mineral, and the same brilliant play of colours; the dominant colours of the scintillations are metallic green, pink, and red. Some of the best specimens form, when polished, very fine gem-stones; but here as elsewhere the valuable specimens obtained bear but a small proportion to the whole. The best have been obtained from Rocky Bridge Creek, Abercrombie River; the matrix is a fine-grained bluish-grey amygdaloidal trachyte, which is so much altered that it can be abraded by the thumb-nail; the opal has filled by infiltration certain of the vesicular cavities and crevices in this rock; it is associated with much common opal free from any play of colour.

The appearance and mode of occurrence of the opal found at Bulla Creek, in Queensland, is very different; the body colour of the Queensland opal is usually deep ultramarine blue or green, and the reflections are usually metallic green and red; the matrix is in this case a brown mottled clay porphyry, in which the opal occurs as small veins and strings.

Opal is also found in a similar clay porphyry in the Wellington District; but up to the present I have only seen very small particles of the precious opal diffused through much valueless opal; also occurs at Bland, near Forbes; also at Coroo, with chalcedony, agates, &c.; and at Bloomfield, near Orange.

Fire Opal or Girasol—(*i.e.*) An opal with a red or orange tint—occurs at Wellington. But little valued.

Common Opal, Semi-Opal, and Wood Opal: Are common in all the basaltic districts; Uralla, Inverell, Richmond River, Trunkey, Scone; Hunter, and Castlereagh Rivers, Kiama, Lachlan River.

Cacholong: Dead white; conchoidal fracture; adheres to tongue. Tumut.

Hyalite: Muller's Glass.

Found coating the joints in basalt, Jordan's Hill, Cudgegong; of a blue colour at Ororal.

Silicified Wood.—Is very abundant over nearly all the basaltic districts; the two have always been observed in close proximity. It is very abundant also throughout the coal measures. Large boulders of such fossilized wood are met with in most of the drifts and river deposits.

Hornblende Group.

HORNBLENDE.—Amphibole.

Chem. comp.: Silica, magnesia, lime, iron, manganese, &c. Oblique system. Different varieties of hornblende vary extremely in colour, form, and composition:—

1. *Tremolite.*—A white or nearly white variety occurs, at Cooma, in long slender crystals.

2. *Actinolite.*—A dark-green fibrous actinolite occurs at Mowembah in quartz.

3. *Sahlite.*—Crystals of this form occur in a compact augite paste on the Cowriga Rivulet.

Large crystals of common hornblende occur at Uralla, Tenterfield, and in New England district, and in other places. In quartz with lamellar magnetite, at Merrendee, on the Meroo, a tributary of the Cudgegong; and on the road from Jungemonia to Uranbeen; also at Cooma.

ASBESTOS.—Amianthus.

Chem. comp.: Magnesium silicate.

A fibrous variety of hornblende.

Said to occur in veins at Bukulla, at Guyong, and Berrada Creek, Wellington. In basalt at the Pennant Hills, near Sydney. With auriferous quarts in diorite at Gulgong; also found at Wentworth, Lucknow Gold Field, Icely; Lewis Ponds Creek, Lachlan River.

PECTOLITE?

Chem. comp.: Aluminium calcium and magnesium silicate. A light-grey and white fibrous mineral, very tough; found at Mount Walker by Mr. Wilkinson, containing casts of *spirifers.* The rock has at the spot where this mineral occurs, been metamorphosed by the intrusion of a vein of igneous rock.

CHLORITE.—Green earth.

Chem. comp.: Hydrous silicate of alumnia and magnesia, with more or less oxide of iron.

In a confused mass of various crystallized substances, Gulgong, Lachlan River.

De Lessite.—A ferruginous chlorite. Its occurrence is mentioned by the Rev. W. B. Clarke.

Serpentine Group.

There are several varieties of the mineral serpentine met with in New South Wales. The rock of the same name is also found very largely developed, both in the Northern, Western, and Southern districts.

SERPENTINE.

Chem. comp.: Hydrous silicate of magnesia.

Of an oil-green colour, semi-transparent, on the Murrumbidgee; at Bingera, Warialda, Barraba, and Stony Batta.

Williamsite.—Apple-green, translucent, somewhat greasy to the touch, takes a very fair polish, and forms very pleasing ornamental stone. H. = 3.

From Tuena.

Marmolite.—A foliated variety of serpentine, occurs on the Murrumbidgee, of a yellowish colour, associated with dull-red and green serpentine rock.

The late Mr. Stutchbury mentions the occurrence of an orbicular serpentine on the Apsley, Manning, and Hastings Rivers or Creeks.

Picrolite.—Chem. comp.: Hydrous magnesium silicate.

A fibrous variety of serpentine. Found at Kelly's Creek, Gwydir River, and in the serpentine at Bingera, with meerschaum. It occurs also as a green striated mineral at Lucknow and Wentworth near Orange.

TALC.

Chem. comp.: Hydrous magnesium silicate. Hexagonal system.

Occurs in the form of hexagonal crystals between Gudgeby River and Naas Valley, also about Bathurst. And from Jungemonia to Uranbeen with steatite and large hornblende crystals.

Steatite.—A massive indurated form of talc or hydrous magnesium silicate.

Occurs in Ranger's Valley, Severn River, at Elsmore, and the Bolitho Tin Mine, associated with tinstone. At Jungemonia and Uranbeen, Icely.

Soapstone, Saponite.—Williams River, Icely.

Agalmatolite, or Chinese Figure Stone—In chlorite schist. Nurembla, Callalia Creek.

Meerschaum.—Chem. comp.: Magnesium silicate. Said to occur on the Richmond River. Very doubtful.

Augite Group.

AUGITE.

Pyroxene.—Chem. comp.: Silica, magnesia, iron, lime, &c. Oblique system. There are several varieties of olivine, which range from white or almost white to dark green, black, and opaque minerals.

Well-formed short columnar crystals of augite are not uncommon. They are abundant at Newstead, Cameron's, and Middle Creeks; near Guntawang; Pretty's Plains, near Molong; and near to the Pigeon House. At Bruno waterfall, Callallia Creek, with mesotype and arragonite in a vesicular and amygdaloidal basalt, which rest upon columnar basalt.

Smaragdite containing native copper, occurs in a hard elvan porphyry at Molong Creek, and near to Dowagarang (the Old Man Canobolas).

Diallage.

Chem. comp.: Calcium and magnesium silicate. Occurs in small bronze-green coloured crystals in the serpentine of Bingera, Warialda, and Kelly's Creek, Gwydir River, with chrome iron. The crystals are thin, and more or less brittle; translucent.

Hypersthene.

Chem. comp.: Calcium, magnesium, and iron silicate. Found near the Lagoons, west of Gulgong.

Chrysolite Peridot.—Olivine.

Chem. comp.: Magnesium silicate. Rhombic system. Transparent bright green coloured specimens of chrysolite are common in most of the gold drifts. Found in the Shoalhaven and Hunter Rivers. Old Trigomon. Associated with the various gems in Gt. Mullen Creek, which falls into the Cudgegong; also at Two-mile Flat, Bingera, and other places. The exterior often has a white opaque enamel-like crust.

Gem Stones.

Corundum.

There are several forms of this substance—alumina. The blue is known as the sapphire, the green as the oriental emerald, the red as the ruby, the hair-brown as adamantine spar, the magenta-coloured as barklyite, and the common dark-coloured ones as corundum and emery.

Sapphire.

Chem. comp.: Alumina or aluminum sesquioxide. Hexagonal system. The usual forms met with in New South Wales are double-sized pyramids, sometimes combined with the basal pninacoid or other pyramids; the prism is less common. Perfect crystals are, however, rare, the majority of the specimens being either fractured or waterworn. There appears to be no record of their having been found *in situ*. In certain cases it would appear from their sharp and unworn edge that they had not travelled very far. H. = 9. Sp. gr. = 3·49 to 3·59.

The New South Wales sapphires, in common with those from other parts of Australia, are usually rather dark in colour; they, however, are found varying from perfectly colourless and transparent, through various shades of blue and green, to a dark and almost opaque blue. One or two green-coloured sapphires or oriental emeralds are almost always met with in every parcel of a hundred or so specimens, also blue and white particoloured.

Asteria or Sapphires which show a six-rayed star of reflected light are by no means uncommon.

Sapphires are almost invariably met with by the miners as an accompaniment of alluvial gold.

They are widely distributed over the New England District, as at Bingera and near Inverell, with tin, adamantine spar, zircons, topaz, and bismuthite; in Vegetable, Cope's and Nundle Creeks, the Gwydir River, Dundee, Uralla, Ben Lomond; Mann's River, the Abercrombie, Namoi, Peel, and Cudgegong Rivers; at Two-mile Flat; in Bell's River and Pink's Creek, with white topaz, almanden garnets, epidote, spinelle, chrysoberyl, chrysolite, hyacinth, etc.; at Tumberumba, with tinstone and other minerals; also in the Shoalhaven and Snowy Rivers.

The late Dr. A. M. Thomson, Professor in the Sydney University, detected a variety peculiar to the Mudgee district, which occurs in uniformly small slightly barrel-shaped hexagonal crystals of about $\frac{1}{4}$-in. long and $\frac{1}{20}$-in. diameter—opaque, and of a peculiar lavender colour.

He made out the composition as follows:—

Analysis.

Alumina	98·57
Iron Sesquioxide	2·25
Lime	·45
	101·27

H. = 9. Sp. gr. = 3·59.

Ruby, or Red Sapphire.

This is much more rare than the blue gem. The late Mr. Stutchbury reports its occurrence with sapphire, chrysolite, hyacinth, amethyst, and other gems in the Cudgegong between Eumbi and Bimbijong, and in Mullen's and Lawson's Creeks which fall into the Cudgegong. And the Rev. W. B. Clarke found it at Tumberumba with similar gems. It is found too at Mudgee, but is not common, and usually of small size; also from a small creek, about

two miles from the head of the Hunter River. Dr. Thomson determined its composition, hardness, and specific gravity to be as follows:—

Analysis.

Alumina	97·90
Iron sesquinoxide	1·39
Magnesia	·63
Lime	·52
	100·44

H. = 9. Sp. gr. = 3·59.

Barklyite.—This name has been given in Victoria to the opaque magnesia-coloured variety.

Adamantine Spar.

Found at Two-mile Flat, Uralla, Bingara, Inverell. When cut and polished *en cabochon* this forms a very handsome ring stone.

Emerald.—Beryl.

Chem. comp.: Silica, aluminium and glucinium. Hexagonal system.

The name emerald is usually reserved for the deep green coloured stones fit for jewellery, while the less beautiful and pale varieties are termed beryls.

The emerald is said to occur mixed with granite detritus in Paradise Creek, and near Dundee. Also in gneissiform dykes on the summit of Mount Tennant, and at Lanyon to the west of that mountain; in the granite at Cooma, and in Mann's River with other gems. In some cases the beryl is probably meant.

The beryl is much more common, it is found at Elsmore associated with quartz and crystals of tinstone. The beryl crystals, which are often very thin and fragile, are seen interlaced with and seated upon tin crystals.

At Ophir the beryl occurs in white felspar with quartz and white mica; one crystal is $\frac{5}{8}$ in. through, of a pale transparent yellow green colour and vitreous lustre. Sp. gr. = 2·708.

A greenish coloured opaque beryl in small hexagonal prisms has been found in the Shoalhaven River east of Bungonia; the crystals are associated with mispickle, and in some cases they penetrate it.

Chrysoberyl.—Cymophane.

Chem. comp.: Glucinum aluminate. Rhombic system.

The late Mr. Stutchbury mentions that he found a fragment of this gem in the Macquarie River.

Zircon, Hyacinth, Jargoon.

Chem. comp. Zirconium silicate. Pyramidal system.

The transparent red varities are known as hyacinths, the smoky jargoon; while the grey, brown, etc., are known as zircons.

This mineral is found in granite on the Mitta Mitta, and on the Moama River, some 4 miles west of Jillamalong Hill.

Zircons are very common in the auriferous river sands and drifts, as at Uralla, Bingera, Two-mile Flat, the Cudgegong, Macquarie, Abercrombie, Shoalhaven, and other rivers.

They are of course usually more or less rolled, but occasionally the crystalline form is well preserved; they vary much in colour, from more or less colourless and transparent through pale-red to crimson, brown, and opaque; they are also found of a clear transparent green, but these are rarer than the others.

Topaz.

Chem. comp.: Aluminium, silica and fluorine. Rhombic system. Occasionally met with in well-formed columnar crystals capped with planes of numerous pyramids. The best-formed crystals are usually perfectly clear, colourless, and transparent. Some very large crystals have been met with; a portion of a large bluish green-coloured crystal found at Mudgee, and now in the Melbourne Technological Museum, weighs several pounds; and others weighing several ounces are by no means rare; they are sometimes 2 to 3 inches long and broad in proportion, especially those from Uralla.

The pale bluish-green tint is the most common colour, sometimes they are slightly yellow.

It is comparatively abundant all over the granite region of New England; it occurs associated with tinstone in veins traversing the eurite and greisen granites near Elsmore and other parts; some of the small crystals found with the tin ore are beautifully developed.

Found also at Bingera, Two-mile Flat, Bathurst; Bell River, also Macquarie, Abercrombie, Shoalhaven, and Lachlan Rivers.

Spinelle.—Spinel Ruby.

Chem. comp.: Magnesium aluminate. Cubical system. Small well-formed octahedra are by no means rare; the colour varies from pale brown, red, deep crimson, green, to black (pleonaste).

It is found in most river deposits containing gold, as in the sands of the Severn and its tributaries, at Uralla, Bingera, Two-mile Flat, Bathurst, Macquarie, and Cudgegong Rivers.

Pleonaste.—Fairly well-formed large crystals of pleonaste with well-marked conchoidal fracture are found in the Lachlan River. One fairly well-formed octohedron, from the Muntabilli River, Monaro district, was remarkable for its channelled faces.

The amorphous black vesicular pleonaste occurring on the Mudgee Diamond Fields was examined by the late Dr. A. M. Thomson; he found it to have the following composition:—

Silica and undecomposed... ...	2·75
Alumina	64·29
Sesquioxide of chromium... ...	4·62
Magnesia	21·95
Protoxide of iron...	4·49
	98·10

Sp. gr. = 3·77.

The colour is dull black, the surface vesicular; no cleavage, but a highly lustrous well-marked conchoidal fracture; streak, grey.

Anhydrous Silicates.

Kyanite.—Disthene.

Chemical composition: Aluminium silicate. Anorthic system. Occurs near to Kangaloolah, an arm of Tuena Creek some 10 miles south of Tuena. In colour it is nearly white, the lustre pearly, in slender flattened brittle crystals.

Stauralite.

Chemical composition: Aluminium silicate. Rhombic system. Occurs in a talcose schist near Bathurst, in the form of small brown prismatic crystals.

Andalusite.

Chemical composition: Aluminium silicate. Rhombic system. A vein of mineral crystallized in rhombic prisms of a pinkish-grey colour occurs in the slate rock to the east of Bungonia. The cleavage is well marked parallel to the O.P. plane; the planes of the prism have a vitreous lustre, but the terminal planes are dull. I hope to have a quantitative analysis of this very interesting mineral finished shortly.

Chiastolite (Andalusite variety of).—Chemical composition. Aluminium silicate; rhombic system. Occurs in granite rock, at Arnprior, Boro (Goulburn), and in small crystals in the slate near Modbury, Shoalhaven.

Epidote.

Chem. Comp. Silica, aluminia, lime, iron, etc.: Oblique system.

Occasionally well-developed columnar crystals have been met with, but I have seen none of large size—also massive. Usually various shades of green.

Found in the Murrumbidgee district, near Mount Tennant; also at Bundian, with glassy felspar and quartz below; the Windindingerie Cataract; at Gedgedzerick; between Jingery, Bobbera, and Pambula; at Bibinluke, and the "Gap" Lewis Ponds; the Shoalhaven River; also to the east of Bungonia; Gulgong; Bathurst; and in the bed of the Gwydir River, and the Ora Ora.

GARNET.

Chem. Comp.: There are several kinds of garnet and they vary in composition, but the most common are silicates of alumina, lime, iron, manganese, and other bases.

Cubical system: The rhombic dodecahedron and the icositetrahedron being the most common.

It is the alumina-lime or common garnet which is most generally met with, especially in the granite ranges, as at Hartley; it is found also at Bingera, at Ponds Creek, and other places near Inverell, at Uralla, in a talc schist at Bathurst, Washpool Creek, near Solferino; Trunkey Creek, Abercrombie River, Coombing Creek Copper Mine, with hyacinth and gold on the Old Trigomon, Moama River, 4 miles west of Jillamalong Hill; at Hardwicke, near Yass.

A dark greenish-brown garnet occurs in large quantities, with magnetic iron ore, at Wallerawang, well crystallized in rhombic dodecahedra, which contains 21·05 per cent. of metallic iron.

TOURMALINE.—Schorl.

Chem. comp.: Very complex, but mainly composed of silicate of alumina, iron, lime, soda, &c., with usually some 3 or 4 per cent. of boracic acid; other substances such as lithia are often present.

Crystallizes in the hexagonal system, usually in the form of prisms having a more or less triangular section, and strongly striated parallel to the principal axis. Large prisms are met with in the New England district, and also in the Murrumbidgee. When the crystals are small and more or less aggregated together into bundles, the mineral is termed schorl; the form of it is common in the granite of New England in the tin district.

Large crystals are found in the South with pegmatite between Mowwat and Burramungee; with tremolite at Jejedzeric in granite.

It is also commonly found associated with gold, diamonds, and other gems in drifts and river deposits, more or less rolled; at times all trace of the original crystallized form is removed.

Mica.

MUSCOVITE, or Potash Mica.

Chem. comp.: Aluminium and potassium silicate. Oblique system.

Large tabular crystals of mica are met with in the coarse-grained granite of the Bathurst District, as at Broadwater and other places on the Macquarie River, and at Cooma and Wheeo; crystals of a golden-coloured mica are also obtained from the same place, and at Orange with crystals of felspar in a pink-coloured granite.

Green mica is common in the granite of New England; the mica entering into the composition of the greisen at Elsmore, and New-stead, and other places is green. Green mica also occurs in the granite of Yarramgun and Ororal.

In the Naas Valley mica is found in large crystals, associated with quartz, felspar, hornblende, tourmaline, and chlorite.

A mammillated bright golden-coloured mica is found in white quartz at Kiandra; this has very much the appearance of rolled gold, for which in fact it has been mistaken; yellow mica also occurs in Frazer's Creek.

A bright-coloured mica with silvery lustre is met with in a manganiferous cement at Buckley's Lead, Two-mile Flat.

Large groups of beautiful plumose crystals of mica occur at Oura Station, Wagga Wagga.

Felspars.

Orthoclase.—Common Felspar.

Chemical composition: Aluminium and potassium silicate. Oblique system. There are several varieties of this mineral: *Common Felspar* includes all the common non-transparent varieties; *adularia*, the sub-transparent forms; opalescent adularia is termed *moonstone;* and *glassy felspar;* or *ice spar* comprises the clear and transparent forms.

Fine well-formed crystals of felspar are almost unknown here, although fairly large and moderately well-developed crystals are not uncommon in the coarse ground granites of the New England, Bathurst, and Southern districts. Simple and compound crystals of an inch or so in length, exposed by weathering, are common in the granite of New England. Dark grey felspar at Mount Walker. Medium sized crystals of *glassy* felspar are reported at Benada Creek, also near Naas, and with quartz at Lanyon to the west of Mount Tennant. Again near "The Pass" Bundian. With mica chlorite and quartz at Windindingerrie Cataract. Acicular crystals of glassy felspar occur in compact felspar at Mount Wingen near the burning part.

Crystallized adularia felspar is plentiful on Mount Lindesay.

Albite.

Chem. Comp.: Aluminium, sodium, and potassium silicates Doubly oblique system.

Occurs in the form of white crystals and massive in New England, near Bingera, also in one or two places near Gulgong, where in one place it is said to be found in association with calcite opal, asbestos, epidote, sphœrosiderite, mispickle, blende, galena, pyrites, and copper pyrites in an auriferous vein traversing a diorite. It occurs crystallized with translucent quartz at Mount Dixon, Dewelamble, Murrumbidgee, and with quartz, chlorite, and green mica on the Coolalamine Plain and at the head of the Yarralumla.

NEPHELINE.

Chem. Comp.: Aluminium, sodium, and potassium silicate.

Hexagonal system. Occurs in amygdaloidal porphyry between the "Pinnacle," Dowagarang, and the Old Man Canobolas, near Wellington.

SPODUMENE.

Chem. Comp.: Aluminium and lithium silicate. Oblique. Mr. Wilkinson reports its probable occurrence at Oura Station, near Wagga Wagga.

HAUYNE.

Chem. comp.: Silica, alumina, soda, lime, and sulphuric acid. Cubical system.

The Rev. W. B. Clarke discovered some small specimens of a blue-coloured mineral which he believed to be hauyne, below the Windindingerie Cataract, in association with flesh-coloured felspar, adularia, quartz, and epidote.

Hydrous Silicates.

CLAYS.

KAOLIN, or China Clay.

Is derived from the decomposition of felspar, and is not uncommon in many parts of the Colony. A deposit of kaolin suitable for the manufacture of the best porcelain is reported to occur at Lambing Flat, King's Plains, and another of a dazzling white colour on a hill near to Rocky Ridge, which is in association with a bright and pretty coloured lavender clay derived from decomposed basalt.

FIRE CLAYS.

Of good quality are common throughout the coal measures; and in the shales, claystone nodules which would probably yield high-class cement are plentiful.

Brick Clays.—Large deposits of clay, which burn to red, white, and intermediate colours, are common in the County of Cumberland, derived from the disintegration of the Wianamatta shale.

Halloysite.

Chem. comp.: Hydrous silicate of alumina.

This is an amorphous earthy mineral, resembling steatite, derived from the decomposition of igneous rocks. Adheres to the tongue, can be scratched and polished by the nail; of various colours—black, brown, grey, green, and red; the black often contains small brilliant white veins. When placed in water the mineral usually falls to pieces, and the edges become translucent.

Specimens of black halloysite are from time to time brought from all parts of the Colony as samples of graphite.

Occurs in railway cutting through decomposed basalt containing chabasite at Reedy and Stony Creeks, Sutton Forest; at Two-mile Flat of a pretty green colour; Carcoar and Lachlan River.

Zeolites.

This group of minerals is distinguished by the property which most of them possess of fusing with intumescence before the blow-pipe, *i.e.*, they boil up, the name being derived from ζηω, to boil, and λιθος, a stone. The are usually found filling the amygdaloidal cavities and crevices in igneous rocks, and never as crystals disseminated through the mass of the rock like pyrites, garnet, or mica. In chemical composition they consist essentially of compound silicates of alumina, the alkaline earths and alkalis; and when treated with acids gelatinous silica is separated.

Stilbite.

Chem. comp.: Hydrous silicate of alumina and lime. Rhombic system. Reported to occur in metamorphic silurian shales at Adelong.

Laumonite.

Chem. comp.: Hydrous silicate of alumina and lime. Oblique system. This mineral occurs in the form of white crumbly prismatic crystals in association with black and white particoloured calcite crystals in the cavities of an amygdaloidal rock on the road between Geringong and Kiama.

There is a pink mineral in slate on the Mudgee Road, found by Mr. Wilkinson, which is probably a laumonite. (For further particulars see Report upon New South Wales, part I., p 20.) On analysis this mineral yielded the following results:—

Silica	53·266
Alumina, and trace of iron oxide ...	22·833
Lime...	11·000
Water of combination	12·646
Specific gravity, between 2–3	100,224

It also occurs as a white powdery mineral in a soft grey-coloured amygdaloidal trachytic rock at Myalla. This mineral may at once be recognized from its readiness to undergo decomposition.

Mesotype.

Chem. comp.: Hydrous silicate of alumina and soda. Found in amygdaloidal basalt. Locality (?)

Scolezite.

Same chem. comp. as the above. Rhombic system. This mineral is found with cylindrical masses of bitter spar in a basalt, Emu Creek, New England. It is distinguished by curling up like a worm before the blowpipe,—hence the name, from *σκωληξ*, a worm.

Analcime, or Cubical Zeolite.

Chem. comp.: Hydrous silicate of alumina and soda. Cubical system. Occurs at Inverell.

Chabasite.

Chem. comp.: Hydrous silicate of alumina, lime, and potash; Hexagonal system: commonly assumes rhombohedral forms. This is perhaps the most abundant of the New South Wales zeolites, and the crystals are often very well developed. It occurs in basalt with delessite at Musclebrook. And in well-formed rhombohedra in trachyte on the Lachlan River; also in an amygdaloidal basalt at Reedy Creek, Sutton Forest; with calcite in a similar rock at Coroo. It also occurs in the cavities of a puce-coloured rock at Fountain Head in simple rhombohedral crystals of a wax-yellow colour, and is associated with a bright orange-coloured powdery mineral and a grey-green steatitic substance; the matrix can be readily cut with a knife, and leaves a shiny streak.

It is also reported from the Talbragar and Abercrombie Rivers, and is present in the basalt of the Illawarra district.

Herschelite.

This is probably only a variety of gmelinite, one of the chabasite group, and occurs with calcite and analcime, crystallized in double hexagonal pyramids at Inverell.

Prehnite.

Chemical Composition: Hydrous silicate of alumina and lime. Rhombic system. Occurs at Emu Creek, New England, of a green colour; and in association with orthoclase felspar and copper ores, at Reedy Creek, Molong.

LIST of Minerals mentioned in the foregoing Paper :—

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APPENDIX.

ABSTRACT OF THE METEOROLOGICAL OBSERVATIONS TAKEN AT THE SYDNEY OBSERVATORY.

LATITUDE 33° 51′ 41″; LONGITUDE 10h 4m 46s; MAGNETIC VARIATION 9° 32′ 45″ East.

JANUARY, 1875.—GENERAL ABSTRACT.

Barometer ... At 32° Faht.	Highest Reading	29·993 inches on 27th, at 7 and 8 a.m.
	Lowest Reading	29·173 „ on the 1st, at 5 p.m.
	Mean Height	29·706

(Being 0·069 inch less than that in the same month on an average of the preceding 16 years.)

Wind ...	Greatest Pressure... ...	13·5 lbs. on the 7th and 13th.
	Mean Pressure	0·7 lb.
	Number of Days Calm ...	0
	Prevailing Direction ...	E.N.E.

(Prevailing direction during the same month for the preceding 16 years, N.E.)

Temperature	Highest in the Shade ...	97·0	On the 29th.
	Lowest in the Shade ...	59·4	On the 3rd.
	Greatest Range	31·5	On the 29th.
	Highest in the Sun ...	136·0	On the 29th.
	Highest in Black Box with Glass Top ...	213·2	On the 29th.
	Lowest on the Grass ...	51·7	On the 3rd.
	Mean Diurnal Range ...	14·5	
	Mean in the Shade ...	72·7	

(Being 1·7 greater than that of the same month on an average of the preceding 16 years.)

Humidity ...	Greatest Amount	100·0	On the 8th.
	Least	36·0	On the 13th.
	Mean	71·0	

(Being 1·9 less than that of the same month on an average of the preceding 16 years.)

Rain	Number of Days	10 rain.	
	Greatest Fall	0·292 inch.	On the 9th.
	Total Fall	0·549 inch.	65 feet above ground.
		1·145 inch.	15 inches above ground.

(Being 3·085 inches less than that of the same month on an average of the preceding 16 years.)

Evaporation	Total Amount	8·622 inches.
Ozone ...	Mean Amount	5·9

(Being 1·5 greater than that in the same month on an average of the preceding 15 years.)

Electricity...	Number of Days Lightning	8
Cloudy Sky	Mean Amount	6·0
	Number of Clear Days ...	3
Meteors ...	Number Observed... ...	0

Remarks.

The rainfall throughout the Colony has been small during the month. Thunderstorms were prevalent—but in many cases no rain fell. On the 7th, at Cape St. George Light-house, balls of bluish fire seen on the lightning conductors. Hot wind at Deniliquin on 5th; and during portion of the month, great haziness in atmosphere observed at most stations.

GOVERNMENT OBSERVATORY, SYDNEY.

LATITUDE 33° 51′ 41″; LONGITUDE 10h 4m 46s; MAGNETIC VARIATION 9° 32′ 45″ East.

FEBRUARY, 1875.—GENERAL ABSTRACT.

Barometer .. At 32° Faht.	Highest Reading	30·023 inches on the 24th, at 9 p.m.	
	Lowest Reading	29·410 „ on the 4th, at 1 p.m.	
	Mean Height	29·794	

(Being the same as that in the same month on an average of the preceding 16 years.)

Wind ...	Greatest Pressure ...	20·5 lbs. on the 4th.	
	Mean Pressure	1·6 lbs.	
	Number of Days Calm ...	0	
	Prevailing Direction ...	S.	

(Prevailing direction during the same month for the preceding 16 years, S.)

Temperature	Highest in the Shade ...	98·9	On the 4th.
	Lowest in the Shade ...	55·1	On the 5th.
	Greatest Range	32·0	On the 4th.
	Highest in the Sun ...	126·7	On the 10th.
	Highest in Black Box with Glass Top ...	220·5	On the 4th.
	Lowest on the Grass ...	51·8	On the 5th.
	Mean Diurnal Range ...	10·7	
	Mean in the Shade ...	69·7	

(Being 1·0 less than that of the same month on an average of the preceding 16 years.)

Humidity ...	Greatest Amount... ...	100·0	On the 11th, 14th, and 19th.
	Least	42·0	On the 4th.
	Mean	81·0	

(Being 6·3 greater than that of the same month on an average of the preceding 16 years.)

Rain... ...	Number of Days	19	
	Greatest Fall	2·357 inch.	On the 5th.
	Total Fall	3·398 inch.	65 feet above ground.
		5·593 inch.	15 inches above ground.

(Being 1·310 inches less than that of the same month on an average of the preceding 16 years.)

Evaporation	Total Amount	3·988 inches.	
Ozone ...	Mean Amount	5·3	

(Being 0·8 greater than that in the same month on an average of the preceding 15 years.)

Electricity...	Number of Days Lightning	1	
Cloudy Sky	Mean Amount	7·9	
	Number of Clear Days ...	0	
Meteors ...	Number Observed ...	0	

Remarks.

The weather during the month has been very unseasonable; cold strong South squalls on the 4th, 5th, and 6th; two-thirds of the whole month wet; and very severe S. gales from 27th to and after end of month, doing great damage to the country districts by floods, causing many wrecks on the coast, and preventing steamers, &c., leaving the ports.

GOVERNMENT OBSERVATORY, SYDNEY.

LATITUDE 33° 51′ 41″; LONGITUDE 10h 4m 46s; MAGNETIC VARIATION 9° 32′ 45″ East.

MARCH, 1875.—GENERAL ABSTRACT.

Barometer ... At 32° Faht.	Highest Reading	30·092 inches	on the 25th, at 9 p.m.
	Lowest Reading	29·507 ,,	on the 14th, at 3 & 4 p.m.
	Mean Height	29·857	

(Being 0·040 inch less than that in the same month on an average of the preceding 16 years.)

Wind ...	Greatest Pressure ...	11·5 lbs.	on the 1st.
	Mean Pressure	0·7 lb.	
	Number of Days Calm ...	0	
	Prevailing Direction ...	N.E.	

(Prevailing direction during the same month for the preceding 16 years, N.E.)

Temperature	Highest in the Shade ...	88·1	On the 3rd.
	Lowest in the Shade ...	59·9	On the 20th and 21st.
	Greatest Range	23·5	On the 3rd.
	Highest in the Sun ...	126·5	On the 8th.
	Highest in Black Box with Glass Top ...	196·9	On the 3rd.
	Lowest on the Grass ...	50·6	On the 21st.
	Mean Diurnal Range ...	10·8	
	Mean in the Shade ...	69·6	

(Being 0·6 greater than that of the same month on an average of the preceding 16 years.)

Humidity ...	Greatest Amount... ...	100·0	On the 1st and 14th.
	Least	45·0	On the 3rd.
	Mean	81·2	

(Being 4·9 greater than that of the same month on an average of the preceding 16 years.)

Rain... ...	Number of Days	21 rain and 2 dew.	
	Greatest Fall	1·953 inch.	On the 2nd.
	Total Fall	4·138 inches.	65 feet above ground.
		6·731 inches.	15 inches above ground

(Being 1·058 inch greater than that of the same month on an average of the preceding 16 years.)

Evaporation	Total Amount	4·087 inches.
Ozone ...	Mean Amount	5·5

(Being 0·6 greater than that in the same month on an average of the preceding 15 years.)

Electricity	Number of Days Lightning	2
Cloudy Sky	Mean Amount	6·5
	Number of Clear Days ...	2
Meteors ...	Number Observed ...	0

Remarks.

The southerly weather which commenced end of last month continued until about the 3rd, the floods being generally to the N.E. portion of the Colony, ruining many farmers, and causing the death by drowning of the Speaker of the Legislative Assembly, on the Paterson River. The latter part of the month has also been wet and very disagreeable, the rainfall being 1·058 inch greater than the average of the last 16 years,—and 21 days out of the month wet in Sydney.

GOVERNMENT OBSERVATORY, SYDNEY.

LATITUDE 33° 51′ 41″; LONGITUDE 10^h 4^m 46^s; MAGNETIC VARIATION 9° 32′ 45″ East.

APRIL, 1875.—GENERAL ABSTRACT.

Barometer At 32° Faht.	Highest Reading	30·273 inches on the 18th, at 9 a.m.	
	Lowest Reading	29·406 „ on the 26th, at 2 a.m.	
	Mean Height	29·861	

(Being 0·147 inch less than that in the same month on an average of the preceding 16 years.)

Wind ...	Greatest Pressure ...	8·0 lbs. on the 14th.	
	Mean Pressure	0·5 lb.	
	Number of Days Calm ...	0	
	Prevailing Direction ...	W.	

(Prevailing direction during the same month for the preceding 16 years, W.)

Temperature	Highest in the Shade ...	78·7	On the 2nd.
	Lowest in the Shade ...	51·3	On the 29th.
	Greatest Range	17·8	On the 13th.
	Highest in the Sun ...	120·3	On the 2nd.
	Highest in Black Box with Glass Top ...	169·0	On the 3rd.
	Lowest on the Grass ...	39·5	On the 29th.
	Mean Diurnal Range ...	11·0	
	Mean in the Shade ...	65·0	

(Being the same as that of the same month on an average of the preceding 16 years.)

Humidity ...	Greatest Amount... ...	100·0	On the 8th, 9th, and 30th.
	Least	54·0	On the 5th.
	Mean	80·5	

(Being 2·5 greater than that of the same month on an average of the preceding 16 years.)

Rain... ...	Number of Days	19	
	Greatest Fall	1·122 inch.	On the 30th.
	Total Fall	4·117 inches.	65 feet above ground.
		4·781 inches.	15 inches above ground

(Being 2·734 inches less than that of the same month on an average of the preceding 16 years.)

Evaporation	Total Amount	3·074 inches.	
Ozone ...	Mean Amount	5·4	

(Being 0·5 greater than that in the same month on an average of the preceding 15 years.)

Electricity	Number of Days Lightning	9	
Cloudy Sky	Mean Amount	7·6	
	Number of Clear Days ...	0	
Meteors ...	Number Observed ...	0	

Remarks.

The weather during the month has been steadier and more agreeable than the previous months of the year. The rainfall is under the average for last 16 years: the coast districts having had considerably more than the districts west of the Main Range. Frost, for the first time this year, recorded at Orange and Queanbeyan (to west of Main Range).

GOVERNMENT OBSERVATORY, SYDNEY.

LATITUDE 33° 51′ 41″; LONGITUDE 10h 4m 46s; MAGNETIC VARIATION 9° 32′ 45″ East.

MAY, 1875.—GENERAL ABSTRACT.

Barometer ...	Highest Reading	30·292 inches on the 25th, at 9 p.m.	
At 32° Faht.	Lowest Reading	29·235 „ on the 12th, at 4 a.m.	
	Mean Height	29·812	

(Being 0·123 inch less than that in the same month on an average of the preceding 16 years.)

Wind ...	...Greatest Pressure... ...	24·5 lbs. on the 13th and 14th.	
	Mean Pressure	0·8 lb.	
	Number of Days Calm ...	0	
	Prevailing Direction ...	W.N.W.	

(Prevailing direction during the same month for the preceding 16 years W.)

Temperature	Highest in the Shade ...	71·1	On the 4th.
	Lowest in the Shade ...	42·6	On the 25th.
	Greatest Range	19·5	On the 25th.
	Highest in the Sun ...	108·8	On the 5th.
	Highest in Black Box with Glass Top	158·2	On the 4th.
	Lowest on the Grass ...	34·9	On the 25th.
	Mean Diurnal Range ...	13·1	
	Mean in the Shade ...	57·0	

(Being 1·5 less than that of the same month on an average of the preceding 16 years.)

Humidity ...	Greatest Amount... ...	100·0	On the 26th, 27th, 28th, & 29th.
	Least	46·0	On the 13th.
	Mean	78·4	

(Being 2·7 greater than that of the same month on an average of the preceding 16 years.)

Rain... ...	Number of Days	14 rain and 4 dew.	
	Greatest Fall	3·895 inches.	On the 29th.
	Total Fall	8·228 inches.	65 feet above ground.
		12·549 inches.	15 inches above ground

(Being 8·402 inches greater than that of the same month on an average of the preceding 16 years.)

Evaporation	Total Amount	1·999 inches.	
Ozone ...	Mean Amount	5·2	

(Being 0·6 greater than that in the same month on an average of the preceding 15 years.)

Electricity...	Number of Days Lightning	7	
Cloudy Sky	Mean Amount	4·3	
	Number of Clear Days ...	8	
Meteors ...	Number Observed ...	0	

Remarks.

The weather during May has been very wet, the average rainfall of last 16 years having been exceeded at Sydney by 8·402 inches. At Eden the rainfall for the month amounted to 17·780 inches (as much as 10·520 inches falling on the 4th). As in last month, the heaviest rains fell on the Coast side of Main Range. Frost has now shown throughout the country districts, and snow fell during the month at Armidale, Murrurundi, Scone, Orange, and Mount Victoria. There was a heavy easterly gale on the 2nd, and very heavy winds on 7th, 13th, 14th, 15th, 28th, and 29th.

GOVERNMENT OBSERVATORY, SYDNEY.

LATITUDE 35° 51′ 41″; LONGITUDE 10^h 4^m 46^s; MAGNETIC VARIATION 9° 32′ 45″ East.

JUNE, 1875.—GENERAL ABSTRACT.

Barometer ...	Highest Reading	30·077 inches on the	4th, at 10 p.m.
At 32° Faht.	Lowest Reading	29·540 „	on the 12th, at 3 p.m.
	Mean Height	29·825	

(Being 0·099 inch less than that in the same month on an average of the preceding 16 years.)

Wind ...	Greatest Pressure... ...	19·8 lbs. on the 26th.	
	Mean Pressure	0·7 lb.	
	Number of Days Calm ...	1	
	Prevailing Direction ...	W.N.W.	

(Prevailing direction during the same month for the preceding 16 years W.)

Temperature	Highest in the Shade ...	70·1	On the 26th.
	Lowest in the Shade ...	42·5	On the 22nd.
	Greatest Range	19·4	On the 23rd.
	Highest in the Sun ...	105·0	On the 2nd.
	Highest in Black Box with Glass Top	140·0	On the 2nd.
	Lowest on the Grass ...	34·5	On the 22nd.
	Mean Diurnal Range ...	12·3	
	Mean in the Shade ...	55·6	

(Being 0·9 greater than that of the same month on an average of the preceding 16 years.)

Humidity ...	Greatest Amount	100·0	On the 3rd, 4th, and 27th.
	Least	48·0	On the 14th.
	Mean	78·6	

(Being 1·6 greater than that of the same month on an average of the preceding 16 years.)

Rain	Number of Days	10 rain and 5 dew.	
	Greatest Fall	2·395 inches.	On the 6th.
	Total Fall	5·579 inches.	65 feet above ground.
		7·818 inches.	15 inches above ground

(Being 2·063 inches greater than that of the same month on an average of the preceding 16 years.)

Evaporation	Total Amount	1·219 inch.
Ozone ...	Mean Amount	4·9

(Being 0·5 less than that in the same month on an average of the preceding 16 years.)

Electricity...	Number of Days Lightning	2
Cloudy Sky	Mean Amount	6·6
	Number of Clear Days ...	3
Meteors ...	Number Observed ...	0

Remarks.

The heavy rains of May continued until about the 7th of the month, then a space of fine enjoyable weather until the 26th, when one of the heaviest seas known on the S.E. Coast for years set in and lasted until the 2nd July; the full force being felt in the neighbourhood of Ulladulla (South of Sydney.) The Wollongong breakwater was seriously damaged by the washing away of four blocks of concrete, each twenty-five tons weight.

GOVERNMENT OBSERVATORY, SYDNEY.

LATITUDE 33° 51′ 41″; LONGITUDE 10h 4m 46s; MAGNETIC VARIATION 9° 32′ 45″ East.

JULY, 1875.—GENERAL ABSTRACT.

Barometer ... At 32° Faht.	Highest Reading	30·537 inches on the 11th, at 10 p.m.	
	Lowest Reading	29·474 ,, on the 29th, at 3 p.m.	
	Mean Height	30·008	

(Being 0·075 inch greater than that in the same month on an average of the preceding 16 years.)

Wind	Greatest Pressure... ...	14·0 lbs. on the 18th.	
	Mean Pressure	0·6 lb.	
	Number of Days Calm ...	0	
	Prevailing Direction ...	W.N.W.	

(Prevailing direction during the same month for the preceding 16 years W.N.W.)

Temperature	Highest in the Shade ...	70·8	On the 14th.
	Lowest in the Shade ...	40·3	On the 17th.
	Greatest Range	20·9	On the 14th.
	Highest in the Sun ...	105·9	On the 14th.
	Highest in Black Box with Glass Top	142·2	On the 14th.
	Lowest on the Grass ...	30·4	On the 17th.
	Mean Diurnal Range ...	13·2	
	Mean in the Shade ...	52·5	

(Being 0·2 greater than of the same month on an average of the preceding 16 years.)

Humidity ...	Greatest Amount... ...	100·0	On the 2nd, 21st, and 22nd.
	Least	49·0	On the 15th and 29th.
	Mean	79·5	

(Being 6·0 greater than that of the same month on an average of the preceding 16 years.)

Rain	Number of Days	15 rain and 4 dew.	
	Greatest Fall	0·909 inch. On the 2nd.	
	Total Fall...	1·057 inch. 65 feet above ground.	
		1·611 inch. 15 inches above ground.	

(Being 2·686 inches less than that of the same month on an average of the preceding 16 years.)

Evaporation	Total Amount	1·583 inch.	
Ozone ...	Mean Amount	5·7	

(Being 0·6 greater than that in the same month on an average of the preceding 14 years.)

Electricity...	Number of Days Lightning	6	
Cloudy Sky	Mean Amount	4·8	
	Number of Clear Days ...	6	
Meteors ...	Number Observed ...	4	

Remarks.

The weather during the month was pleasant and agreeable. The rainfall at Sydney was 2·686 inches below the July average of last 16 years. Shocks of earthquake felt at Eden, Twofold Bay, on 11th and 16th, and gales, fogs, frosts, snow, hail, and thunderstorms at some of the country stations.

GOVERNMENT OBSERVATORY, SYDNEY.

LATITUDE 33° 51′ 41″; LONGITUDE 10h 4m 46s; MAGNETIC VARIATION 9° 32′ 45″ East.

AUGUST, 1875.—GENERAL ABSTRACT.

Barometer At 32° Faht.	Highest Reading	30·248 inches on the 27th, at 8 a.m.
	Lowest Reading	29·308 „ on the 31st, at 3 p.m.
	Mean Height	29·834

(Being 0·115 inch less than that in the same month on an average of the preceding 16 years.)

Wind ...	Greatest Pressure... ...	23·1 lbs. on the 20th.
	Mean Pressure	0·7 lb.
	Number of Days Calm ...	0
	Prevailing Direction ...	W.

(Prevailing direction during the same month for the preceding 16 years W.)

Temperature	Highest in the Shade ...	81·8	On the 20th.
	Lowest in the Shade ...	41·0	On the 14th.
	Greatest Range	26·5	On the 18th.
	Highest in the Sun ...	115·1	On the 20th.
	Highest in Black Box with Glass Top	157·7	On the 18th.
	Lowest on the Grass ...	30·7	On the 11th.
	Mean Diurnal Range ...	17·3	
	Mean in the Shade ...	57·3	

(Being 3·0 greater than of the same month on an average of the preceding 16 years.)

Humidity ...	Greatest Amount... ...	96·0	On the 19th.
	Least	32·0	On the 18th.
	Mean	68·8	

(Being 3·0 less than that of the same month on an average of the preceding 16 years.)

Rain ...	Number of Days	4 rain and 5 dew.	
	Greatest Fall	0·211 inch.	On the 9th.
	Total Fall...	0·337 inch.	65 feet above ground.
		0·520 inch.	15 inches above ground.

(Being 2·466 inches less than that of the same month on an average of the preceding 16 years.)

Evaporation	Total Amount	3·839 inches.
Ozone ...	Mean Amount	5·6

(Being 0·7 greater than that in the same month on an average of the preceding 14 years.)

Electricity	Number of Days Lightning	8
Cloudy Sky	Mean Amount	4·9
	Number of Clear Days ...	3
Meteors ...	Number Observed ...	5

Remarks.

The rainfall during this month has been very small (although more than the August totals of 1859 and 1871), being 2·466 inches below the average of the preceding 16 years. Snow and heavy frosts prevalent in the country districts. Thunder and hail storms at Sydney and some of the country stations, and hot winds at Sydney 16th, 18th, and 20th; at Port Macquarie on 20th; Scone, 15th and 29th; Mount Victoria, 19th; and at Moruya and Bodalla on the 30th.

GOVERNMENT OBSERVATORY, SYDNEY.

LATITUDE 33° 51′ 41″. LONGITUDE 10h 4m 46s. MAGNETIC VARIATION 9° 32′ 45″ East.

SEPTEMBER, 1875.—GENERAL ABSTRACT.

Barometer At 32° Faht.	Highest Reading	30·289 inches on the 23rd, at 9 a.m.	
	Lowest Reading	29·420 „ on the 8th, at 6 & 7 a.m.	
	Mean Height	29·907	

(Being 0·019 inch greater than that in the same month on an average of the preceding 16 years.)

Wind ...	Greatest Pressure ...	14·6 lbs. on the 21st.	
	Mean Pressure	0·7 lb.	
	Number of Days Calm ...	0	
	Prevailing Direction ...	W.N.W.	

(Prevailing direction during the same month for the preceding 16 years, W.)

Temperature	Highest in the Shade ...	88·5	On the 21st.
	Lowest in the Shade ...	41·1	On the 5th.
	Greatest Range	30·7	On the 8th.
	Highest in the Sun ...	122·1	On the 21st.
	Highest in Black Box with Glass Top ...	169·7	On the 20th.
	Lowest on the Grass ...	35·9	On the 4th.
	Mean Diurnal Range ...	17·7	
	Mean in the Shade ...	57·4	

(Being 1·2 less than that of the same month on an average of the preceding 16 years.)

Humidity ...	Greatest Amount	93·0	On the 14th and 22nd.
	Least	27·0	On the 21st.
	Mean	68·0	

(Being 0·8 less than that of the same month on an average of the preceding 16 years.)

Rain	Number of Days	11 rain and 2 dew.	
	Greatest Fall	0·724 inch.	On the 14th.
	Total Fall	1·058 inch.	65 ft. above ground.
		1·700 inch.	15 in. above ground.

(Being 0·559 inches less than that of the same month on an average of the preceding 16 years.)

Evaporation	Total Amount	4·983 inches.	
Ozone ...	Mean Amount	5·9	

(Being 0·8 greater than that in the same month on an average of the preceding 14 years.)

Electricity ...	Number of Days Lightning	7	
Cloudy Sky	Mean Amount	4·4	
	Number of Clear Days ...	1	
Meteors ...	Number Observed ...	2	

Remarks.

The rainfall during the month, although small, has only been 0·559 inch below the average of preceding 16 years: the temperature has also been below the average. Frost showing itself at some of the country stations, and very heavily at Hunter's Hill, a few miles from Sydney, on the 4th. Snow at Scone on 17th; Mount Victoria 1st, 2nd, and 14th; and Moss Vale, 1st and 14th. Hot winds at Lambton, 21st; Wentworth 5th and 8th, and Sydney 20th and 21st. Thunderstorms prevalent, and a shock of earthquake felt at Moss Vale on the 25th at 9·30 p.m from west to east.

GOVERNMENT OBSERVATORY, SYDNEY.

LATITUDE 33° 51′ 41″; LONGITUDE 10h 4m 46s; MAGNETIC VARIATION 9° 32′ 45″ East.

OCTOBER, 1875.—GENERAL ABSTRACT.

Barometer ... At 32° Faht.	Highest Reading	30·128 inches on the 6th, at 9 a.m.	
	Lowest Reading	29·282 „ on the 31st, at 4·17 p.m.	
	Mean Height	29·732	

(Being 0·116 inch less than that in the same month on an average of the preceding 16 years.)

Wind ...	Greatest Pressure ...	13·5 lbs. on the 21st.	
	Mean Pressure	0·8 lb.	
	Number of Days Calm ...	0	
	Prevailing Direction ...	S.	

(Prevailing direction during the same month for the preceding 16 years, N.E.)

Temperature	Highest in the Shade ...	84·9	On the 15th.
	Lowest in the Shade ...	50·3	On the 22nd.
	Greatest Range	28·9	On the 1st.
	Highest in the Sun ...	125·2	On the 14th.
	Highest in Black Box with Glass Top ...	183·0	On the 18th.
	Lowest on the Grass ...	42·4	On the 4th.
	Mean Diurnal Range ...	15·4	
	Mean in the Shade ...	64·5	

Being 1·0 greater than that of the same month on an average of the preceding 16 years.)

Humidity ...	Greatest Amount... ...	92·0	On the 2nd, 20th, and 25th.
	Least	31·0	On the 1st.
	Mean	68·8	

(Being 0·7 greater than that of the same month on an average of the preceding 16 years.)

Rain... ...	Number of Days	11 rain and 1 dew.	
	Greatest Fall	0·404 inch.	On the 10th.
	Total Fall	0·500 inch.	65 feet above ground.
		1·055 inch.	15 inches above ground.

(Being 1·562 inch less than that of the same month on an average of the preceding 16 years.)

Evaporation	Total Amount	6·489 inches.
Ozone ...	Mean Amount	6·0

(Being 0·8 greater than that in the same month on an average of the preceding 15 years.)

Electricity...	Number of Days Lightning	7
Cloudy Sky	Mean Amount	6·3
	Number of Clear Days ...	1
Meteors ...	Number Observed ...	4

Remarks.

The weather during the month was hot and dry, with low barometer, and less than half the average rainfall. Brilliant meteors were seen on the 5th and 26th.

In the country there was generally a moderate rainfall, and at some of the Southern Stations it was abundant. Snow was seen on the mountains near Scone, and near Orange, on the 21st.

GOVERNMENT OBSERVATORY, SYDNEY.

LATITUDE 33° 51′ 41″; LONGITUDE $10^h\ 4^m\ 46^s$; MAGNETIC VARIATION 9° 32′ 45″ East.

NOVEMBER, 1875.—GENERAL ABSTRACT.

Barometer ... At 32° Faht.	Highest Reading	29·952 inches	on the 7th, at 12 p.m.
	Lowest Reading	29·139 „	on the 2nd, at 3 p.m.
	Mean Height	29·633	

(Being 0·199 inch less than that in the same month on an average of the preceding 16 years.)

Wind ...	Greatest Pressure... ...	31·2 lbs. on the 2nd.	
	Mean Pressure	0·9 lb.	
	Number of Days Calm ...	0	
	Prvailing Direction ...	W.	

(Prevailing direction during the same month for the preceding 16 years N.E.)

Temperature	Highest in the Shade ...	86·2	On the 6th.
	Lowest in the Shade ...	51·6	On the 8th.
	Greatest Range	30·8	On the 23rd.
	Highest in the Sun ...	124·8	On the 18th.
	Highest in Black Box with Glass Top	196·2	On the 18th.
	Lowest on the Glass ...	41·4	On the 8th.
	Mean Diurnal Range ...	18·3	
	Mean in the Shade ...	68·1	

(Being 1·8 greater than that of the same month on an average of the preceding 16 years.)

Humidity ...	Greatest Amount... ...	100·0	On the 13th.
	Least	31·0	On the 2nd and 4th.
	Mean	61·6	

(Being 8·0 less than that of the same month on an average of the preceding 16 years.)

Rain ...	Number of Days	10	
	Greatest Fall	0·322 inch.	On the 17th.
	Total Fall...	0·614 inch.	65 ft. above ground.
		0·881 inch.	15 in. above ground.

(Being 2·779 inches less than that of the same month on an average of the preceding 16 years.)

Evaporation	Total Amount	8·981 inches.
Ozone ...	Mean Amount	5·6

(Being 0·6 greater than that in the same month on an average of the preceding 15 years.)

Electricity...	Number of Days Lightning	9
Cloudy Sky	Mean Amount	5·9
	Number of Clear Days ...	3
Meteors ...	Number Observed ...	1

Remarks.

The weather during the month has been remarkably dry and warm, with prevalent westerly winds. Barometer 0·199 inch below, and temperature 1·8 above the average. The rainfall has been very small indeed, 2·779 inches below the average, and less than that for any November since 1867.

At the coast stations north and south of Sydney, a moderate amount of rain fell, but inland the weather has been very dry. On the south coast of Australia the rainfall has been very abundant.

GOVERNMENT OBSERVATORY, SYDNEY.

LATITUDE 33° 51′ 41″; LONGITUDE $10^h\ 4^m\ 46^s$; MAGNETIC VARIATION 9° 32′ 45″ East.

DECEMBER, 1875.—GENERAL ABSTRACT.

Barometer ... At 32° Faht.	Highest Reading	30·215	On the 20th, at 9 a.m.
	Lowest Reading	29·039	On the 27th, at 4 and 5 p.m.
	Mean Height	29·662	

(Being 0·137 inch less than that in the same month on an average of the preceding 16 years.)

Wind ...	Greatest Pressure... ...	21·1 lbs. on the 5th.	
	Mean Pressure	1·0 lb.	
	Number of Days Calm ...	0	
	Prevailing Direction ...	E.N.E.	

(Prevailing direction during the same month for the preceding 16 years N.E.)

Temperature	Highest in the Shade ...	95·5	On the 1st.
	Lowest in the Shade ...	51·7	On the 9th.
	Greatest Range	32·2	On the 1st.
	Highest in the Sun ...	132·0	On the 1st.
	Highest in Black Box with Glass Top	193·7	On the 3rd.
	Lowest on the Grass ...	42·2	On the 8th
	Mean Diurnal Range ...	17·9	
	Mean in the Shade ...	70·7	

(Being 1·3 greater than that of the same month on an average of the preceding 16 years.)

Humidity ...	Greatest Amount... ...	98·0	On the 31st.
	Least	28·0	On the 28th.
	Mean	60·9	

(Being 9·6 less than that of the same month on an average of the preceding 16 years.)

Rain	Number of Days	9	
	Greatest Fall	0·947 inch.	On the 31st.
	Total Fall	1·300 inch.	65 feet above ground.
		1·867 inch.	15 inches above ground.

(Being 0·470 inch less than that of the same month on an average of the preceding 16 years.)

Evaporation	Total Amount	10·764 inches.
Ozone ...	Mean Amount	5·3

(Being 0·8 greater than that in the same month on an average of the preceding 15 years.)

Electricity...	Number of Days Lightning	8
Cloudy Sky	Mean Amount	5·8
	Number of Clear Days ...	2
Meteors ...	Number Observed ...	6

Remarks.

The weather at Sydney during the month was very dry and hot with very little rain, excepting a heavy thunderstorm on the morning of the 31st, and the supply of water in the suburbs has been very short. Hot winds were experienced on the 1st, 5th, 6th, and 28th, and although the prevalent wind was from the sea, E.N.E., the humidity was low and the evaporation nearly 11 inches. Hail fell on the 8th. In the Western Districts the weather was unusually dry and hot, with prevalent W. and N.W. winds. At most of the stations the rainfall was less than half an inch, and the losses from the drought very great. At the Southern stations there was more rain, especially on the coast.

Sydney: Thomas Richards, Government Printer.—1876.